Critical Issues/ Drinking Water

Problèmes critiques-l'eau potable

84- 4507 /

NATIONAL CONFERENCE ON CRITICAL ISSUES IN DRINKING WATER QUALITY

FEBRUARY 6 & 7, 1984

OTTAWA, ONTARIO

INTRODUCTION

I have the pleasure of introducing the following proceedings of the conference, 'Critical Issues in Drinking Water Quality' held in Ottawa, February 6 & 7, 1984.

We were delighted with the participation and the quality of the conference.

I think you will find each of the 19 speakers' presentations exciting and stimulating from Kristin Shannon's definition of what makes a critical environmental issue, through to Maarten Schalekamp's analysis of the European treatment process.

We have received a tremendous number of positive comments on both the presentations and the need for this type of interchange.

I would especially like to thank the Health Protection Branch of Health and Welfare for their financial support to make this event possible and to Pollution Probe and C.E.L.A. for their overall direction and assistance on the steering committee.

In his presentation on the last day of the conference, Victor Kim, Director of EPA's Office of Drinking Water, who has lived through the U.S. experience of implementing a safe drinking water act, observed that Canada, by sponsoring a conference with such disparate groups in an informal and reasoned exploration of the issues, prior to the development of legislation, was off to a good start.

The 1980's will see public attention focus on water as one of our most critical resources. Conferences such as this will play a crucial role in providing the necessary and informed background to ensure that governmental policy is a precurser to enlightened resource strategies.

David Simpson
Executive Director
Federation of Associations on the Canadian Environment (FACE)

PROGRAM
MONDAY, FEB. 6, 1984

9:00 Official Opening and Address
Opening Address: Dr. Alex Morrison
A.D.M. Health Protection Branch
Health & Welfare Canada

9:30 Speaker: Mr. Blair Seaborn
Co-Chairman, International Joint Commission
"Some Critical Issues in Water Supply for Canada"

10:15 Coffee

10:30 Chairpersons: Mr. Ron Hicks, Province of N.B.
Mr. Ken Roberts, Province of Ontario
Panel - The Quality of Existing Water Systems and Public Perception
Mr. Paul Emery
Director, Toronto Water Supply

Dr. Ross Hall
Prof. Biochemistry
McMaster University

Dr. Kristin Shannon
Canadian Trend Report
Montreal, Quebec

12:30 Luncheon and Speaker Mr. David Kirkwood
Deputy Minister, Health and Welfare
"Developing and Maintaining National Standards in Health and Drinking Water"

2:00 Chairpersons: Dr. Peter Toft, H.P.B.
M. Clement Audet, Prov. of Quebec
Speaker: Dr. Robert Harris
Princeton, NJ
"Public Interest and Water, U.S. Experience"

2:45 Panel - Hazards in Drinking Water
Mr. Roy Hickman
Health Protection Branch
Dr. Joe Cotruvo, Director
Office of Drinking Water Supply
Dr. Pierre Payment
Institute Armand Frappier, Quebec

4:00 Discussion

5:00 Cash Bar

PROGRAM
TUESDAY, FEB. 7, 1984

9:00 Chairpersons: Dr. Richard Tobin, H.P.B.
Mr. Bill Bailey, Province of B.C.

Technologies for Treatment
Speaker: Mr. Bob Goodings
Gore and Storrie
"History of Water Treatment in Canada"

9:30 Speaker: Dr. Maarten Schalekamp
Director of Zurich Water Supply
Zurich, Switzerland
"European Alternatives and Experience"

10:15 Coffee

10:30 Chairpersons: Dr. Andrew Benedek, Zenon Environmental Ltd.
Mr. Kelly Kjartanson, Province of Manitoba

Panel - The Alternate Technologies
Dr. Jack DeMarco
Activated Carbon
City of Cincinnati

Dr. Rip Rice
Ozone Treatment
Consultant, Maryland

Dr. Lee Wikstrom
Point of Use Filters
Water Quality Association

12:30 Lunch

1:30 Chairpersons: Mr. David Simpson, F.A.C.E.
Ms. Toby Vigod, C.E.L.A.

Public Policy for Drinking Water
Speaker: Dr. Victor Kim
Asst. Deputy Administrator, EPA
"Issues in Water Quality from the US Perspective"

2:15 Panel - Perspectives on Regulation and Drinking Water
Mr. Doug Edward
President, C.E.L.A.
Dr. Emmanuel Somers
Director General, Health Protection Branch
Mr. Kai Millyard
Researcher, Pollution Probe

4:00 Discussion

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F.A.C.E.
190 Somerset St. W.
Suite 206
Ottawa, Ontario
K2P 0J4

(613) 230 7575

TABLE OF CONTENTS

PAGE

1. Introduction i

2. Conference Program ii

3. Official Opening and Addresses 1

4. Speakers Presentations

Dr. Alex Morrison 6
Mr. Blair Seaborn 17
Mr. Paul Emery 36
Dr. Ross Hall 45
Dr. Kristin Shannon 50
Mr. David Kirkwood 71
Dr. Robert Harris 78
Mr. Roy Hickman 90
Dr. Joe Cotruvo 99
Dr. Pierre Payment 118
Mr. Bob Goodings 132
Dr. Maarten Schalekamp 139
Dr. Jack DeMarco 170
Dr. Rip Rice 205
Dr. Lee Wikstrom 241
Dr. Victor Kimm 256
Mr. Doug Edward 269
Dr. Emanuel Somers 290
Mr. Kai Millyard /Ms. Joanna Kidd 299

5. Steering Committee Members 320

6. List of Speakers 321

7. List of Participants 325

OPENING ADDRESS:

David Simpson, Executive Director, FACE

Jean-Paul Lanctôt, President, FACE

Toby Vigod, Researcher, C.E.L.A.

Colin Isaacs, Executive Director, Pollution Probe

Monday, February 6, 1984

Official Opening and Address

David Simpson
Executive Director, FACE

I would like to extend a warm welcome to everyone. Those of you who came for 'Winterlude' and have managed to make your way through the slush that we had for you, I was promised by the weatherman that it is going to be freezing tonight so you will be able to enjoy the festivities of the Canal.

For the Canadian registrants, I'd like to welcome them. We have registrants from our furthest west province of British Columbia through to Newfoundland on the east. I won't get into the argument of where the Trans-Canada Highway starts, whether it starts in the east or the west. We have an ongoing debate in our society whether the Trans-Canada starts at point zero at the furthest-most point of the Island in Victoria or the furthest-most point of Newfoundland. We have people from the Northwest Territories and through to southern Ontario.

To our international guests, I'd like to welcome Dr. Schalekamp from Zurich through to the Mason Dixie line in the United States, and last night I met somebody from California. We have quite a few people that have come a long way to discuss this important subject.

Before I call upon officials from FACE, the Federation of Assocations on the Canadian Environment, C.E.L.A., the Canadian Environmental Law Association, Pollution Probe, and the Health Protection Branch of Health and Welfare to officially open the conference, I would just like to congratulate the sponsoring agencies and the registrants for so enthusiastically endorsing the issues of this conference. It is so aware that such diverse groups are joining the public policy debate to explore the range of critical issues in drinking water. Our hope is that the issues we have picked will be fairly explored with a great deal of criticality. With this desire for toughness of debate and discussion, there goes a cautionary note. I know there are differing opinions even on insignificant points. I want to ensure that it is incumbent on all of us that there is a need to both respect and listen to the counterpoint of views.

We are delighted as well to have members of the Federal-Provincial Drinking Water Guidelines Committee here, and to have some of them chairing various sessions. This morning, we have a couple of overview speakers who will provide some thoughts on the current state of water quality in Canada. If you take your program, the yellow package in your docket, I just briefly would like to give you an overview of what we are going to try to accomplish during the conference. This morning you can see we have a couple of overview speakers. Following that, we have a panel that will explore the topic of quality of existing water systems and some of the trends on the public perception of water quality. This afternoon's sessions will provide us with some generalist technical overviews on the hazards showing up in drinking water. Tomorrow morning, our session will explore the history and practice of water treatment in Canada, followed by a review of the European experience in treating their water and the rationale for that.

The panel will explore the treatment technologies of granular-activated carbon ozone and the point to use filters. Then, on Tuesday afternoon, after providing you with the overviews, the hazards, the technologies - now the tough part: what, if anything, to do about it.

The public policy forum for that discussion on where do we go from here, a safe drinking water act, what type of guidelines, maintain the status quo or other alternatives. So, if by tomorrow afternoon you think that you are getting off the hook, that's when it all starts! We expect you to listen to the evidence presented and respond in tomorrow afternoon's session.

As you can see, we have a full and challenging next couple of days, and with the two-and-a-half minutes of free time provided, we want you to go out on the Canal and skate and enjoy our frozen and safe water during the Winterlude festivities.

Just a technical point: if you have any specific problems or details, talk to the people with the white ribbons. They are organizers of the conference and should be able to help you out on that. We have simultaneous translation, and you can take, at the back of the room, a receiver for hearing. And we have a no-smoking policy except for the last six rows at the right-hand side of the room and we can move that around, expand it or decrease it as the need occurs. I think that's it. I would like to now call upon Mr. Jean-Paul Lanctôt, the président de Face, to say a few opening remarks.

Jean-Paul Lanctôt
President, FACE

Our distinguished guests, ladies and gentlemen! I am proud to join the other representatives of the various groups that are sponsoring this conference - National Health and Welfare, C.E.L.A., and Pollution Probe - to welcome you all to this National Conference on Potable Water. I am sure that you will not regret your participation as the conference committee has succeeded to attract some of the best speakers in that field who will enlighten you on this very important subject - potable water.

FACE is a federation grouping six regional, provincial associations, all engaged in the preservation and quality improvement of our real water resources. Within its objectives, FACE has to promote better utilization of our environmental resources and to provide a forum for discourse and communiation in matters of common interest to the constituent regional associations at a national level. Today's conference is a typical example of how FACE reaches its goals.

L'année dernière face a organiser conjointement avec le cas, un seminaire sur les affaires gouvernementales, à cette occasion, une pleine demi-journée a été consacrée aux problèmes de l'eau potable ou a la résource "eau" en général. Dr. Somers, Mr. Roy Hickman et notre directeur exécutif de FACE Mr. Dave Simpson, trois des participants d'aujourd'hui ont chacun donné une conférence. Et ce sujet a levé tellement d'interêt, qu'il a donné la nécessité d'organiser aujourd'hui un symposium de deux jours sur ce sujet.

FACE a aussi entrepris de préparer un programme d'entrainement pour les operateurs d'usine d'eau potable, ce programme est maintenant presque termine et plusieus des modules qui en font partie ont déjà été imprimés et publiés.

No longer can we be confident about the continued availability of fresh, unpolluted and usable water as was said recently by Mr. Caccia from Environment Canada. Let's make sure that everyone who is concerned with this issue remembers this threat.

Thanks for your presence and enjoy the conference!

Toby Vigod,
C.E.L.A.

I would like to welcome everyone to the conference and just say a few words about C.E.L.A. Canadian Environmental Law Association is a public interest environmental law group. We were founded in 1970 and we act on behalf of individuals and citizens groups who can't otherwise afford private lawyers on environmental matters.

In 1980, C.E.L.A. decided to focus, where possible, its cases and its law-reform efforts in the areas of toxic chemicals, hazardous wastes and pesticides. The chemical contamination in drinking water was an important focus of our work. Specifically, C.E.L.A. has been involved in, first of all, representing Pollution Probe and Operation Clean working in Niagara involving a chemical case, High Park. We have also been involved in representing citizens groups in Toronto concerned with dredge and fill activities in that harbour, and we have been involved in numerous cases involving people living near leaky landfills and the problems of contamination of both ground and surface water.

In the area of law reform, Canadian Environmental Law Association in conjunction with Pollution Probe, has written an article on the need for a safe drinking water act and outlined the principles that such an act were to contain.

C.E.L.A. is pleased to be a co-sponsor of this conference and trusts that the program that we have helped plan will generate initiatives to be undertaken to ensure that drinking water will be protected in Canada. Thank you!

Colin Isaacs
Executice Director, Pollution Probe

Thank you very much, David! Ladies and gentlemen, on behalf of the Pollution Probe Foundation I too would like to join in welcoming you here today. The Pollution Probe Foundation is a charitable organization concerned with protecting and improving the Canadian environment. We were the first Canadian public interest organization to raise the acid rain issue as far back as 1970. It took about ten years to get a national conference assembled on acid rain. As far as we know, we were the first public interest organization to raise the issue of toxic organic chemicals in drinking water. That was just two years ago! And I want to thank Health and Welfare Canada, FACE and C.E.L.A. and particularly David Simpson for enabling this conference to take place so much more quickly. As we say in environmental organizations, this issue is really rolling.

As a charity, I have to put in a quick commercial. We are able to continue our work only with the help of literally thousands of organizations and individuals across Canada. We'll have a table in the lobby during coffee break with some of our publications, our brochures and our magazine, Probe Post, Canada's Environmental Magazine. And I hope you'll stop by and take a look at what we do over and above our concerns about drinking water.

Finally, I want to tell you that we do more than just raise issues. Through our new book, called "Profit from Pollution Prevention," we are actively trying to encourage industry to recycle and reduce as much as possible of the toxic organic wastes that industry produces. Through our campaign to preserve Lake Ontario it has just been announced today that we have reached an agreement with ESA Chemical Services Incorporated and with the Department of Environmental Conservation in the State of New York that will result in a phased, state-wide ban on the landfilling of most toxic organic chemicals in New York State. We believe that this agreement is a major step towards ensuring that we will not create new sources of toxic-organic chemical contamination of Lake Ontario. Thank you very much!

DR. ALEX MORRISON

A.D.M. HEALTH PROTECTION BRANCH
HEALTH AND WELFARE CANADA

IS CANADA'S DRINKING WATER SAFE ?

Is Canada's Drinking Water Safe?

Mesdames, Mesdemoiselles, Messieurs,

Au nom du Ministre de la Santé nationale et du bien-être social, l'honorable Monique Bégin, je vous souhaite la bienvenue à ce congrès. A mon avis, c'est une occasion assez importante - il s'agit d'un sujet vraiment vaste et complexe - un sujet d'une grande importance pour la vie humaine - la qualité de l'eau potable.

La ministre m'a demandé de vous transmettre ses regrets de ne pouvoir assister à cette conférence.

It is indeed a pleasure for me to be here today to welcome you to this National Conference on Critical Issues in Drinking Water Quality. I especially wish to thank those from the Federation of Associations on the Canadian Environment (FACE), the Canadian Environmental Law Association (C.E.L.A.), and Pollution Probe, since those organizations joined National Health and Welfare in sponsoring this conference. My thanks also to those who have agreed to be speakers or panelists at this conference, some of whom have travelled from other countries.

If there is a single most critical issue related to drinking water quality, it is, I believe, reflected in the question I have posed as the title of my presentation: Is Canada's Drinking Water Safe? Once can hardly overemphasize the importance of the question. In this country, blessed with perhaps 25% of the world's supply of fresh water, we tend to forget the obvious, or at least take it for granted: an abundant supply of safe, wholesome water supports and enriches life. Conversely, unsafe water is a threat to health and life itself.

We tend to forget also that the amount of water in the world is fixed, amounting to approximately 1500 million cubic kilometres in all. The hydrologic cycle continually recycles water from sea to land, and back to the sea again, thus keeping the quantity of fresh water relatively fixed, at about 0.2% of the total, on a world basis.

In Canada, as elsewhere, early settlements were located near water. Although available fresh water supplies were often sadly abused and neglected, in our pioneer days as a nation, our water resources were ample for all purposes. Increasing population growth, urbanization and industrialization have all combined to put pressure on the fixed resources of fresh water locally available. Though we live in a largely empty land, of our major metropolitan areas only Edmonton is located more than 160 km from the international border with the United States. Pressure on available water resources is, of course, accentuated under situations where we share a body of water with our American neighbors, or when our water supply can be influenced by actions which they take. Under such circumstances, what they do, or do not do, to safeguard the quality of the water supply may have a much greater impact on the quality of our water than do our own actions. The current problems with chemical dumps in various places around the Great Lakes illustrate our joint national responsibilities for drinking water quality.

Another principle of water management should perhaps also be stated again. We talk somewhat glibly about the need for "pure" water, by which most mean to infer "wholesome" water. Water which is pure in the chemical sense is not found anywhere in nature. Water is known for good reason as the universal solvent, readily absorbing gases, and dissolving inorganic and even organic compounds. Indeed, anyone who has ever drunk double-distilled chemically pure water knows that it is tasteless, flat and insipid. Good-tasting water depends upon its content of inorganic ions for its esthetically pleasing qualities. Certain of these inorganic chemical constituents, at the right concentrations, may, indeed, be beneficial for health, as witnessed by the relationships between the prevention of fluoride and dental caries, or the possible protective effect of hard water on the incidence of cardiovascular disease.

To most people, however, the mention of chemicals and drinking water brings to mind terms such as pollution, cancer, and disease. These dark visions are reinforced by the results of recent epidemiological studies which have noted associations between increased incidence of various cancers and the consumption of chemically contaminated waters. Although all such studies to date are limited by flaws in the experimental design, they provide important insights into areas where more research is needed. I am unaware of Canadian data on long-term changes in the chemical quality of water, but it is instructive to note that chloride concentrations in the Rhine river increased linearly from about 15 mg/litre in 1875 to about 200 mg/litre a century later, and that annual ice layers from areas of Greenland, identifiable back to about 1200 A.D., reflect an increase in metallic contamination of 70% to 1870, of 210% by the 1950's and of 460% by the 1960's. This demonstrates the way contaminants can move vast distances by air.

One of the major public health advances of history occurred in the 19th century, when industralized Western societies began to provide clean water and sanitary waste disposal systems for their urban populations. As a result, bacterial contamination is, in the main, adequately controlled by current water treatment and monitoring practices. These have traditionally revolved around coagulation, sedimentation, filtration and disinfection. Unfortunately, we know much less about the potential for viral contamination of drinking water. Enteric viruses have indeed, been found in finished Canadian drinking water which was bacteriologically safe. Although research is underway in this area, there are as yet no Federal or Provincial guidelines on viruses in drinking water.

The major thrust of governments in Canada in response to concerns about water quality has been to clean up our waterways, and to exert better control over the disposal of those hazardous substances that eventually find their way into our drinking water supplies. These are laudable objectives but there is a growing concern that these efforts alone cannot assure the safety of our water for decades to come. Many of the substances of concern are extremely persistent and are already in the waters or sediments of our lakes and rivers. Many of the aquifers that supply wells are already contaminated by leaching from toxic waste disposal sites and municipal landfill sites. Even if the means were available to prevent further contamination of them, they would remain so for long periods of time.

In a recent survey entitled "Public Perceptions of Water Quality in the Great Lakes", the public generally considered that water quality is changing for the worse. Over half of those polled thought that the level of government effort devoted to water quality improvement was inadequate. The public was equally dissatisfied with the adequacy of existing regulations governing water pollution and efforts to enforce pollution regulations.

One visible manifestation of the public concern over drinking water quality is the phenomenal rise in sales of point-of-use treatment devices. One estimate puts current sales of these devices at about 40,000 units annually, with a retail value of well over 4 million dollars. In a recent survey of the metropolitan centres in Canada, about 3% of homes used some kind of in-home device to treat the municipal water supplies. About half of the homes that employ such devices use activated carbon filters -- a type that is of concern to the Health Protection Branch because of their ability to support bacterial growth, such as that of Pseudomonas aeruginosa. In Regina, a city where water quality problems are notorious, activated carbon filters are used in approximately one in every 6 houses.

There are a number of current developments in the drinking water field that will demand increasing attention in the next few years. They include the following:

(i) Standards

The first Federal standards for drinking water were promulgated in 1923, and related to the bacterial quality of water used for drinking and culinary purposes in ships on the Great Lakes. It was not until 1968 that the first Canadian drinking water standards were developed through a cooperative effort between the Federal Government, the Provinces and the Canadian Public Health Association. They covered certain microbial and physical characteristics, radionuclides, and some inorganic and organic chemicals. As more information accumulated on safety of chemicals, and more sensitive analytical methodology was developed, the need for modification and update of the standards became apparent. The Guidelines for Canadian Drinking Water Quality, 1978, listed more than 50 physical and chemical parameters. Maximum Acceptable Concentrations and, for toxic constituents much lower Objective Concentrations were listed. These latter are intended to provide long-term goals and are set at the limits of analytical detectability. In essence, they represent the ultimate in drinking water quality.

Publication of new WHO standards in mid-1983 which include a number of organic substances not presently covered in the Canadian guidelines gives added impetus to demands to increase the scope of the current guidelines, which are now being revised and extended. There is also increasing pressure from environmental organizations and others for legally enforceable natural standards for drinking water quality. It may not be feasible, however, to monitor regularly for large number of chemicals at very low concentrations, for the purpose of enforcement.

(ii) Surveillance

Standards for Maximum Acceptable Concentrations of chemicals in water are of no practical public health value unless they are adhered to. This of course requires periodic monitoring of water supplies to ensure they comply with quality specifications. Responsibility for this function lies with the Provinces and municipalities. Recent enquiries indicate that at least in late 1982 there was considerable variability in the extent to which surveillance activities were carried out.

(iii) Ground water quality

Ground water, the source of supply for most small communities and rural homes in Canada, has generally been regarded as safe from contamination and as requiring minimum treatment before use. This assumption is now in question.

Organic compounds such as trichloroethylene, trichloroethane, chloroform, carbon tetrachloride, and benzene have been found in the ground waters of almost all American States east of the Mississipi River at concentrations much higher than those found in surface water supplies. Only limited data are available for Canadian ground water supplies but these indicate that the situation may be better than that in the Eastern U.S., although a few local problems are known. Since it generally takes ground water sources a longer time to purify themselves, contamination problems are difficult to deal with. Detection of the nature and extent of ground water contamination is often difficult and expensive (due to the costs of drilling monitoring wells).

(iv) Treatment Chemicals

It is not generally appreciated that drinking water is highly "processed". Modern treatment plants subject water to a variety of technological processes such as coagulation and flocculation, softening, filtration, pH control, disinfection, oxidation and fluoridation. Applying data from a U.S. survey (1981) to the average production (119 gallons per person per day) by Canadian municipal plants, one can calculate that about 1 million tons of chemicals are used annually for water treatment purposes. There are no purity requirements for water treatment chemicals in Canada. In contrast, in the U.S., work is under way in developing a "Water Chemicals Codex" which will specify minimal acceptable purity specifications for such chemicals.

(v) Plumbing and other materials in contact with water

The use of lead pipes, long known as a source of exposure to this toxic metal (especially in soft water areas), was discontinued several decades ago but some may still be in service today, mainly in older urban cores. Newer materials that have come into use include asbestos-cement, asphalt and bituminous coating materials and a variety of plastics. Until 1980, the Department of National Health & Welfare assessed the suitability of the products of various manufacturers for use in potable water distribution systems. This service was discontinued in 1980 because of resource constraints, and since it was not required by law. Complaints from manufacturers and from municipal and provincial governments followed. It is evident that Canadian manufacturers are at a disadvantage even in the Canadian market because U.S. companies can promote their products in Canada on the basis of approval by the U.S. Environmental Protection Agency.

(vi) Point-of-Use Water Treatment Devices

I've already mentioned the sharp increase in the use of these devices and Departmental concerns over those which utilize activated carbon filters. Other types of point-of-use water treatment devices also have their own limitations and operating constraints. For example, ultraviolet light devices require sensitive monitors to ensure adequate u.v. dosage, and iodine-releasing devices may not be appropriate for long-term use because of the physiological effects of iodine. The Department has encouraged "self-regulation" by working closely with the Canadian Water Quality Association (to which 95% of water treatment device manufacturers belong) in devising a code of practice for the industry with respect to device performance and advertising. It is, as yet, too early to judge the success (or otherwise) of this approach but the indications to date are that it will have only limited success.

(vii) Disinfection

With the discovery about ten years ago that chlorination of drinking water can give rise to very low levels of carcinogenic halogenated organic by-products, including trihalomethanes, there has been renewed interest in alternative disinfection methods. However, the reaction products of alternative disinfectant substances, such as ozone, are still largely unidentified, although epoxy by-products have been postulated.

(viii) Treatment Technology

Conventional water treatment processes are designed primarily to cope with bacteriological contamination and to remove inorganic ions. Their effectiveness against viruses or in removing organic contaminants is largely unknown. Newer processes to reduce or remove trihalomethanes involving, for example, alternative oxidants, off-line storage and pre-treatment aeration, ion-exchange resins, granular activated carbon and powdered activated carbon involve extensive modifications to existing plants and increased capital cost for new plants. Research and development leading to inexpensive effective treatments is urgently needed.

I have not as yet talked about legal responsibilities for assuring the safety of drinking water in Canada. We certainly do not suffer from insufficient numbers of Acts and Regulations! There are 15 major water-related pieces of Federal legislation and 82 pieces of Provincial legislation - nearly 100 Acts totally! The Federal government has power to legislate over a number of specific matters affecting waters, and for planning and managing water resources where there is "a significant national interest". For potable water, the provinces and municipalities have the primary responsibility in matters relating to watershed and aquifer protection, and in the construction, maintenance and operation of waterworks and water distribution systems, with the exception of those which are part of Federal works and undertakings.

The Federal government provides leadership in developing health guidelines for water constituents. Extensive Federal/Provincial cooperation and coordination is, of course, essential if these diverse responsibilities are to be met properly. This is accomplished through a Federal/Provincial Advisory Committee reporting to the Conference of Deputy Ministers of Health.

In closing, I return to the question posed at the beginning: Is Canadian Drinking Water Safe? The answer cannot be given simply, given the uncertainties and inadequacies of the data base available, and indeed, the limitations of science itself. Any answer must, therefore, be tentative, recognizing that today's best judgement will undoubtedly be rendered obsolete and out of date by tomorrow's advances in knowledge. What then can be said? On a national basis, there is not at present sufficient evidence to indict drinking water as an imminent threat to public health in Canada. Nevertheless, the price of safety is eternal vigilance. We need additional research, more monitoring, enhanced surveillance, to provide the information needed to ensure Canadians that their drinking water, the very stuff of life, continues to be wholesome and safe.

MR. J.B. SEABORN

INTERNATIONAL JOINT COMMISSION

SOME CRITICAL ISSUES IN WATER SUPPLY FOR CANADA

FOR THE NEXT TWO DAYS, YOU WILL BE DEVOTING YOUR FULL ATTENTION TO THE SUBJECT OF DRINKING WATER. YOU HAVE ASSEMBLED FOR THE PURPOSE REPRESENTATIVES OF A RANGE OF ORGANIZATIONS CONCERNED IN VARIOUS WAYS WITH THE PROVISION AND THE QUALITY OF POTABLE WATER, PLUS AN ARRAY OF SCIENTIFIC AND TECHNICAL EXPERTISE FROM THIS CONTINENT AND OVERSEAS. YOU WILL BE CONCENTRATING ON THE CANADIAN SITUATION AND THE CANADIAN NEED, BUT YOU WILL BE MINDFUL OF THE PROBLEM OF DRINKING WATER ON A GLOBAL BASIS -- AND IN MANY PARTS OF THIS GLOBE A FAR MORE BASIC AND CRITICAL PROBLEM THAN WE FACE HERE IN CANADA.

IN LISTENING TO YOUR SPEAKERS AND IN DISCUSSIONS AMONG THE PARTICIPANTS, YOU WILL UNDOUBTEDLY BE PREOCCUPIED BY THE MOUNTING EVIDENCE OF THE EXISTENCE, IN THE DRINKING WATER SUPPLIES OF SO MANY PARTS OF THIS COUNTRY, OF A BEWILDERING VARIETY OF HEAVY METALS AND TOXIC SUBSTANCES. THE QUANTITIES REFERRED TO WILL BE MINUTE AND THE STRESS WILL BE ON THE GREAT SCIENTIFIC UNCERTAINTY WHICH SURROUNDS THE SIGNIFICANCE OF THESE MINUTES QUANTITIES. IN WHAT QUANTITIES, AND INGESTED OVER WHAT PERIOD OF TIME, ARE THEY OR ARE THEY LIKELY TO BE INJURIOUS TO HUMAN HEALTH? TO WHAT EXTENT CAN WE REASONABLY EXTRAPOLATE FROM THE LABORATORY SITUATION TO

THE REAL LIFE SITUATION, THE MORE SO IN THE ABSENCE OF RELIABLE EPIDEMIOLOGICAL DATA? FOR A FEW SUBSTANCES, WE HAVE REASONABLY RELIABLE EXPERIMENTATION AND INFORMATION AS TO LONG-TERM HEALTH EFFECTS; BUT WHEN ARE WE LIKELY TO HAVE THAT INFORMATION FOR THE THOUSANDS OF SUBSTANCES WHICH OUR SKILLS IN DETECTION CAN NOW IDENTIFY? AND WHAT DO WE KNOW OF THE SYNERGISTIC EFFECTS OF THE ALMOST LIMITLESS COMBINATIONS OF THESE SUBSTANCES?

THE COURSE OF PRUDENCE INDICATES TO MOST KNOWLEDGEABLE PEOPLE THAT WE SHOULD HAVE AT LEAST AS OUR LONG-TERM GOAL THE VIRTUAL ELIMINATION FROM OUR WATER SUPPLIES OF ALL SUCH SUBSTANCES WHICH DO NOT OCCUR THERE NATURALLY, WHETHER BY STOPPING THEIR INPUT OR BY TREATING THE WATER SO AS TO NEUTRALIZE THE EFFECT. GIVEN THE PAUCITY OF OUR KNOWLEDGE, HOWEVER, IT IS NOT UNREASONABLE TO ASK HOW MUCH WE SHOULD BE WILLING TO PAY FOR THE ATTAINMENT OF THE GOAL, AND TO THINK OF THAT COST NOT JUST IN DOLLAR TERMS BUT IN TERMS OF OTHER FOREGONE OPPORTUNITIES -- FROM EMPLOYMENT GENERATION TO INFRASTRUCTURE CREATION IN OTHER AREAS TO MEDICAL RESEARCH AND SERVICES. YES, OF COURSE, A SUPPLY OF SAFE DRINKING WATER MUST BE A MOST BASIC HUMAN OBJECTIVE, BUT HOW "SAFE" IS IT TO BE? WE ARE LED STRAIGHT TO THAT VERY DIFFICULT QUESTION, WHICH CALLS MORE FOR A SOCIAL-POLITICAL ANSWER

THAN A SCIENTIFIC ONE: WHAT IS AN "ACCEPTABLE LEVEL OF RISK" WHERE DRINKING WATER IS CONCERNED?

LET ME LEAVE THAT QUESTION WITH YOU FOR THE MOMENT. I'LL COME BACK LATER TO THE MATTER OF WATER QUALITY. BUT BEFORE LETTING YOU GET ON WITH THE MORE ERUDITE SPEAKERS WHO ARE TO FOLLOW IN THESE TWO DAYS, I WANT YOU TO PAUSE WITH ME TO THINK OF DRINKING WATER IN THE BROADEST CONTEXT OF THE NATURAL RESOURCE, WATER, AND HOW WE SHOULD BE RELATING TO IT AND MANAGING IT FOR ALL ITS MULTIPLE USES AND USERS.

WE ARE BLESSED IN THIS COUNTRY WITH ONE OF THE LARGEST ENDOWMENTS OF FRESH WATER IN THE WORLD. AND BECAUSE, SINCE THE EARLIEST ARRIVAL OF WHITE EXPLORERS AND SETTLERS ON THIS LAND, THEY AND THEIR DESCENDANTS SAW LAKES AND STREAMS AND RIVERS ALMOST WHEREVER THEY LOOKED, WE HAVE TENDED TO TAKE WATER AND ITS LIFE-SUPPORTING CHARACTERISTICS FOR GRANTED. EACH ADDITIONAL USE MADE OF IT APPEARED TO HAVE SUCH A MINOR IMPACT ON A SEEMINGLY UNLIMITED RESOURCE THAT WE TREATED IT INDEED AS A FREE GOOD. WATER MANAGEMENT BECAME SYNONOMOUS WITH ENGINEERING MEASURES OF CAPTURE AND DELIVERY. WATER WAS A RESOURCE TO BE EXPLOITED, NOT SOMETHING THAT, IN THE MACRO SENSE, NEEDED TO BE CONSERVED OR TO BE USED SPARINGLY. YES, OF

POWER, TRANSPORTATION AND EVEN WATER INTAKES OFTEN RELY HEAVILY ON THE TOP FEW INCHES OR FEET, AND THEREFORE ON THE CURRENT FLOWS RATHER THAN THE STOCK OF WATER. NOR SHOULD IT BE FORGOTTEN THAT THE NATIONAL AVERAGE OF SUPPLY IS FAR FROM BEING EVENLY DISTRIBUTED IN TIME AND PLACE.

OUR WATER IS PUT TO A MULTITUDE OF USES. IN-STREAM REQUIREMENTS INCLUDE FISH AND WILDLIFE MAINTENANCE, NAVIGATION, OUTDOOR RECREATION, HYDRO-ELECTRIC POWER AND WASTE ASSIMILATION, EVEN THOUGH IT IS DIFFICULT IF NOT IMPOSSIBLE TO QUANTIFY THE AMOUNTS FOR THESE PURPOSES. WITHDRAWALS ARE MORE READILY QUANTIFIABLE. IN CANADA, THE LARGEST WITHDRAWALS ARE FOR THERMO-ELECTRIC POWER PRODUCTION AND MANUFACTURING ACTIVITIES, FOLLOWED BY LESSER AMOUNTS FOR IRRIGATION (A FAR SMALLER PROPORTION THAN IN THE USA) AND DOMESTIC AND MUNICIPAL PURPOSES. MOST WATER WITHDRAWN -- THOUGH NOT ALL -- RETURNS SOONER OR LATER TO A STREAM CHANNEL WHERE IT IS AVAILABLE FOR FUTURE USE, BUT OFTEN OF COURSE IN A CHANGED CONDITION, FOR EXAMPLE, HEATED OR POLLUTED, WITH A CONSEQUENT LIMITATION ON THE TYPE OF FURTHER USE.

RECOGNITION OF THE FACT THAT CANADA'S RENEWABLE WATER RESOURCE SUPPLY IS NOT LIMITLESS, AND THAT THE MULTIPLICITY OF DEMANDS ON ITS USE ARE SOMETIMES IN

CONFLICT, MUST LEAD TO THE EXAMINATION OF A NUMBER OF IMPORTANT QUESTIONS:

(A) HOW ARE WE TO RECONCILE CONFLICTING USES, E.G., PROPOSALS FOR A SIGNIFICANT INCREASE IN DIVERSIONS OF GREAT LAKES WATERS TO ASSIST WATER-SHORT AREAS IN THE USA; OR SIGNIFICANT INCREASES IN CONSUMPTION OF THAT WATER FOR MANUFACTURING OR THERMO-ELECTRIC POWER PRODUCTION *VERSUS* HYDRO-ELECTRIC POWER PRODUCTION OR THE NEEDS OF NAVIGATION?

(B) WHERE WITHDRAWALS AND EVEN MORE SO CONSUMPTION ARE CONCERNED, CAN WE CONTINUE MUCH LONGER TO TREAT WATER AS A FREE GOOD, OR SHALL WE HAVE TO CONSIDER SOME CONTROLS OVER ITS USE BY THE PRICING MECHANISM OR OTHER, PERHAPS REGULATORY, MEANS?

(C) WHERE WE ARE LOOKING AT BOUNDARY OR TRANSBOUNDARY WATERS SHARED BY CANADA AND THE USA, HOW BEST (I.E., IN WHAT RELATIVE AMOUNTS AND UNDER WHAT LEGAL-ECONOMIC FRAMEWORK) CAN WE ALLOCATE SUPPLIES BETWEEN THE TWO COUNTRIES AND VARIOUS USERS?

(D) WILL IT BE NECESSARY TO DEVELOP IN BOTH COUNTRIES A BROAD STRATEGY FOR THE USE OF OUR FRESHWATER RESOURCES?

(E) IF ONE IS TO LOOK AT WHAT THE USER DOES TO THE QUALITY AS WELL AS THE QUANTITY OF THE WATER. (WATER WITHDRAWN AND RETURNED IN ITS PRISTINE STATE IS A FAR CRY FROM WATER WITHDRAWN AND RETURNED IN POLLUTED CONDITION) HOW ARE WE TO APPROACH THE QUESTION OF COSTS OR CONTROLS?

LET ME ASSURE YOU THAT THESE ARE NOT THEORETICAL OR HYPOTHETICAL QUESTIONS. THEY ARE INCREASINGLY BEING ADDRESSED AS SERIOUS MATTERS BY THE GOVERNMENTS, THE PRESS AND THE PEOPLE OF THIS COUNTRY.

SINCE STARTING TO PREPARE THESE REMARKS FOR YOUR CONSIDERATION TO-DAY, THREE EVENTS HAVE OCCURRED WHICH, GIVEN THE GREAT IMPORTANCE I ATTACH TO WATER MANAGEMENT IN ALL ITS ASPECTS, GIVE ME CAUSE FOR ENCOURAGEMENT. LATE IN JANUARY, THE GLOBE AND MAIL RAN A THOUGHTFUL SERIES OF ARTICLES BY MICHAEL KEATING ON OUR WATER RESOURCES, THEIR QUANTITY AND THEIR QUALITY, AND SUBSEQUENTLY DEVOTED TWO LEAD EDITORIALS TO THE SAME SUBJECT. SECONDLY, PREMIER

DAVIS OF ONTARIO HAS CALLED AN INTERNATIONAL CONFERENCE FOR JUNE OF THIS YEAR TO DISCUSS THE HEAVY DEMAND FOR GREAT LAKES WATER AND THE IMPLICATIONS WHICH SUCH DEMAND CARRIES FOR ENVIRONMENTAL QUALITY AS WELL AS MANY ECONOMIC INTERESTS. THIRDLY, THE FEDERAL MINISTER OF THE ENVIRONMENT HAS ANNOUNCED THE APPOINTMENT OF AN ADVISORY COMMITTEE ON FEDERAL WATER STRATEGIES, CHAIRED BY DR. PETER PEARSE OF THE UNIVERSITY OF BRITISH COLUMBIA, WHICH WILL STUDY CANADIAN WATER RESOURCE ISSUES AND, IN THE SUMMER OF 1985, ADVISE THE FEDERAL GOVERNMENT ON LONG-TERM STRATEGIES TO MANAGE THE ISSUES WITHIN ITS JURISDICTION.

THE INTERNATIONAL JOINT COMMISSION IS CURRENTLY SEIZED OF THE QUESTION OF WATER QUANTITY IN A VERY IMPORTANT REGIONAL SENSE. A FEW YEARS AGO, THE U.S. AND CANADIAN GOVERNMENTS ASKED THE COMMISSION TO LOOK INTO THE MATTER OF DIVERSIONS TO AND FROM THE GREAT LAKES, AS WELL AS THE CONSUMPTIVE USES OF GREAT LAKES WATER. WE WERE ASKED TO DETERMINE WHAT EFFECTS THESE WERE HAVING ON GREAT LAKES LEVELS AND WHETHER THE CHANGES IN LEVELS COULD BE MODERATED BY FURTHER CONTROL STRUCTURES AND MECHANISMS.

WE SET UP A TECHNICAL BOARD OF U.S. AND CANADIAN EXPERTS TO EXAMINE THE MATTER FOR US, AND IN DUE COURSE THEY REPORTED BACK. THE GIST OF THEIR REPORT WAS THAT

CONTROL STRUCTURES AND MECHANISMS COULD HAVE LITTLE EFFECT ON LEVELS, CERTAINLY NOT AT AN ECONOMIC COST, AND CERTAINLY NOT IN COMPARISON WITH THE EFFECTS OF NATURAL PHENOMENA. BUT THEY DID POINT OUT THAT A PROJECTION OF EXISTING TRENDS IN CONSUMPTION OF GREAT LAKES WATER COULD, OVER A PERIOD OF SOME DECADES, LEAD TO A REDUCTION IN GREAT LAKES LEVELS OF UP TO A FOOT. THE SIGNIFICANCE OF SUCH A DROP FOR NAVIGATION AND HYDRO-ELECTRIC POWER GENERATION WILL NOT ESCAPE YOU. THE BOARD RECOMMENDED AT MINIMUM A CLOSE MONITORING OF THE TREND IN CONSUMPTIVE USES TO SEE WHETHER IT MIGHT BECOME NECESSARY TO BEGIN TO EFFECT SOME CONTROLS OVER WHAT WE HAVE TENDED TO REGARD AS A FREE GOOD.

IN JUNE, MY COLLEAGUES AND I CONDUCTED A SERIES OF PUBLIC MEETINGS IN SEVEN U.S. AND CANADIAN CITIES AROUND THE GREAT LAKES TO HEAR WHAT INTERESTED PERSONS AND GROUPS HAD TO SAY ABOUT THIS QUESTION, PREPARATORY TO OUR REPORTING BACK TO THE TWO GOVERNMENTS. WE FOUND THAT, SINCE WE WERE FIRST ASKED TO LOOK INTO THE MATTER IN 1977, THERE WAS A STRONGLY HEIGHTENED PUBLIC INTEREST IN THE DISPOSITION OF GREAT LAKES WATERS, BE THAT BY WAY OF DIVERSION OUT OF THE BASIN OR BY THE VIRTUALLY UNCONTROLLED USE FOR ENERGY, INDUSTRIAL, MUNICIPAL AND AGRICULTURAL PURPOSES. THERE WAS A FULLER REALIZATION

THAT UNTRAMMELLED USE BY SOME WAS GOING TO HAVE AN ADVERSE AND LIMITING EFFECT ON USE BY OTHERS, AND FOR OTHER PURPOSES. IN OTHER WORDS, THERE WAS A RECOGNITION THAT THE RESOURCE WAS NOT AN UNLIMITED ONE AND THAT A BALANCE HAD TO BE STRUCK, BY ONE MEANS OR ANOTHER, AMONG THE DIVERSE USES TO WHICH THAT WATER COULD BE PUT.

WE ARE NOW DRAFTING OUR REPORT TO GOVERNMENTS IN WHAT IS SURELY A KEY ENVIRONMENTAL AND RESOURCE MANAGEMENT AREA. I CANNOT PREDICT, OF COURSE, WHAT THAT REPORT WILL SAY, AND WHAT THE IJC MAY RECOMMEND. I AM PERSUADED PERSONALLY, HOWEVER, THAT NOW OR LATER BOTH THE IJC AND, MORE IMPORTANTLY, OUR TWO GOVERNMENTS AND THE PEOPLE OF THE TWO COUNTRIES, WILL HAVE TO FACE THOSE QUESTIONS WHICH I POSED A FEW MOMENTS AGO.

I DO NOT THINK IT IS AN EXAGGERATION TO SAY THAT THE MANAGEMENT OF OUR WATER RESOURCES MAY WELL BECOME AS IMPORTANT AN ISSUE IN THE DECADES AHEAD AS OUR USE OF ENERGY HAS BEEN OVER THE LAST DECADE. THAT MANAGEMENT MUST MAKE POSSIBLE THE SUSTAINABLE USE OF THE RESOURCE OVER A LONG PERIOD, FOR THE MULTIPLICITY OF USERS. AS THE U.N. WORLD CONSERVATION STRATEGY PUTS IT,

> "WATER RESOURCES SHOULD BE UTILIZED IN SUPPORT OF ECONOMIC ADVANCEMENT IN A MANNER WHICH SUSTAINS THE AVAILABILITY AND QUALITY OF THE RESOURCE AND ITS ECOLOGICAL DEPENDENCIES."

IN OTHER WORDS, CONSERVATION AND DEVELOPMENT ARE TO BE SEEN AS MUTUALLY SUPPORTIVE, RATHER THAN ANTAGONISTIC. CONSERVATION IS A POSITIVE FORCE IN THE DEVELOPMENT PROCESS, TO ENSURE THAT DEVELOPMENT IS SUSTAINABLE INTO THE FUTURE.

YOU WILL BE RELIEVED TO KNOW THAT I AM NOT ASKING YOU TO COME UP, IN THE NEXT TWO DAYS, WITH ANSWERS TO THE RANGE OR SET OF QUESTIONS WITH WHICH THE WATER QUANTITY PLANNERS AND MANAGERS ARE NOW WRESTLING. WHAT I WANT TO EMPHASIZE, HOWEVER, IS THAT IN ADDRESSING THE MATTER OF DRINKING WATER YOU ARE TACKLING ONLY ONE ASPECT -- ALBEIT A HIGHLY IMPORTANT, INDEED THE MOST IMPORTANT ASPECT OF WATER USE -- OF THE WISE USE OF THE WATER RESOURCES OF THIS COUNTRY AND OF THIS CONTINENT.

LET ME NOW STEER YOU BACK TO SOME OF THE BASIC AND NO LESS DIFFICULT QUESTIONS WITH WHICH YOU WILL BE WRESTLING THROUGHOUT THIS CONFERENCE, THE QUESTIONS OF WATER QUALITY AS THEY APPLY TO HUMAN CONSUMPTION OF

WATER. HERE AGAIN, AND BEFORE COMING TO THE CONCLUSION THAT TO-DAY'S WATER QUALITY PROBLEMS ARE QUITE IMPOSSIBLY COMPLEX, IT MAY BE WORTH PUTTING THEM ALSO INTO A BIT OF HISTORICAL AND EVEN GEOGRAPHIC PERSPECTIVE.

THE ORGANIZATION OF WHICH I AM PRESENTLY CANADIAN CHAIRMAN, THE INTERNATIONAL JOINT COMMISSION, WAS CREATED BY TREATY BETWEEN CANADA AND THE UNITED STATES -- THE BOUNDARY WATERS TREATY OF 1909. IT WAS ESTABLISHED PRIMARILY TO DEAL WITH THE LEVELS AND FLOWS OF BOUNDARY AND TRANSBOUNDARY WATERS, AND TO ENSURE THAT STRUCTURES AND WORKS UNDERTAKEN TO SERVE THE PURPOSES OF THOSE ON ONE SIDE OF THE BORDER SHOULD NOT BE TO THE DETRIMENT OF THOSE ON THE OTHER SIDE OF THE BORDER. IN MANY WAYS (AND I SHALL NOT GO INTO ALL THE DETAILS HERE), THE TREATY WAS REMARKABLY FAR-SIGHTED IN TERMS OF INTERNATIONAL LAW AND THE OBLIGATIONS OF STATES WITH RESPECT TO THEIR NEIGHBOURS WHERE SHARED WATERS WERE CONCERNED. I WOULD, HOWEVER, IN THIS GATHERING DRAW YOUR ATTENTION TO ONE PARTICULARLY SIGNIFICANT CLAUSE WHICH DEALT NOT WITH WATER QUANTITY BUT WITH WATER QUALITY. THAT PHRASE READS AS FOLLOWS:

> "IT IS FURTHER AGREED THAT THE WATERS HEREIN DEFINED AS BOUNDARY WATERS AND WATERS FLOWING ACROSS THE BOUNDARY SHALL NOT BE POLLUTED ON

> EITHER SIDE TO THE INJURY OF HEALTH OR PROPERTY ON THE OTHER."

AND A LITTLE FARTHER ON, AFTER STATING THAT EACH OF THE PARTIES "SHALL HAVE EQUAL AND SIMILAR RIGHTS IN THE USE OF THE WATERS HEREINBEFORE DEFINED AS BOUNDARY WATERS," THE TREATY ASSIGNS AN ORDER OF PRECEDENCE TO THE BASIC USES TO WHICH SUCH WATERS CAN BE PUT. USES "FOR DOMESTIC AND SANITARY PURPOSES" TAKE CLEAR PRIORITY OVER NAVIGATION, CANALS, POWER AND IRRIGATION, TO LIST ONLY THE IDENTIFIED USES.

THUS AT THE BEGINNING OF THIS CENTURY, IN A DOCUMENT DEALING PRIMARILY WITH WATER QUANTITY, STRONG AND UNEQUIVOCAL SUPPORT WAS GIVEN TO KEEPING WATER FREE OF POLLUTION AND TO RECOGNIZING THE PRIMORDIAL IMPORTANCE OF A SUPPLY OF WATER APPROPRIATE TO MAN'S MOST BASIC NEEDS. NOR IS THIS SURPRISING. TO THOSE OF US HERE OF AT LEAST MY AGE AND INDEED OLDER, IT HAS BEEN TAKEN FOR GRANTED FOR ALMOST AS LONG AS WE HAVE LIVED THAT, BY AND LARGE, WATER TAKEN FROM THE TAP OF VIRTUALLY ANY MUNICIPALITY IN CANADA WAS "SAFE" TO DRINK, IN THE SENSE THAT IT WAS NOT GOING TO LEAD TO UPSET STOMACHS AND DID NOT CARRY COMMUNICABLE DISEASES.

WE IN THIS CONTINENT DO NOT FACE THE BASIC, PRIMITIVE PROBLEM OF SO MUCH OF MANKIND ELSEWHERE. WE DON'T HAVE TO WORRY, AT LEAST NOT ON A NATIONAL OR EVEN A REGIONAL BASIS, ABOUT WHETHER WE CAN DRINK OUR WATER WITHOUT IMMEDIATE RISK OF DYSENTERY, CHOLERA AND THE LIKE. YET NOT MANY DECADES AGO, INDEED AT THE TURN OF THIS CENTURY, AS WE NOW TEND TO FORGET, THERE WERE FREQUENT OUTBREAKS OF SUCH AFFLICTIONS AND DISEASES ON THIS CONTINENT PRECISELY BECAUSE THE TAP WATER WAS NOT ALWAYS SAFE TO DRINK.

SUCH WAS THE CONCERN OF THE TWO FEDERAL GOVERNMENTS THAT IN 1912 THE NEWLY-FORMED COMMISSION WAS ASKED TO ADVISE UPON THE EXTENT OF TRANSBOUNDARY POLLUTION AND WAYS TO REMEDY OR PREVENT POLLUTION AS REQUIRED BY THE TREATY OF 1909. THE COMMISSION IN DUE COURSE REPORTED THAT ITS COMPREHENSIVE SURVEY DISCLOSED "A SITUATION ALONG THE FRONTIER WHICH IS GENERALLY CHAOTIC, EVERYWHERE PERILOUS, AND IN SOME CASES DISGRACEFUL." GOVERNMENTS ACCEPTED THE REPORT AND ASKED THE COMMISSION TO DRAFT A CONVENTION TO CONFER UPON THE COMMISSION THE NECESSARY AUTHORITY TO REMEDY EXISTING CONDITIONS. THE IJC SUBMITTED ITS DRAFT, WHICH BECAME THE BASIS FOR NEGOTIATIONS BETWEEN CANADA AND THE USA BUT FOR REASONS TOO LONG TO DETAIL, THE NEGOTIATIONS CAME TO AN END WITH no convention being signed. A new Reference from governments after World War II on the deteriorating quality of the Great Lakes led the Commission to recommend adoption of "Objectives for Boundary Water Control." This advice was accepted and the IJC was given a monitoring role, but the quality of the waters went from bad to worse. Under continued prodding from the Commission, particularly with respect to the condition of the connecting channels (St. Marys, St. Clair, Detroit and Niagara Rivers), governments in 1964 made yet another Reference, this time on the lower lakes and the international portion of the St. Lawrence. The IJC confirmed that the lower lakes were in trouble and were suffering from severe eutrophication caused primarily by an excessive input of phosphorus. And this finding, coinciding as it did with a more widely expressed concern about the state of our environment in the late 'sixties and early 'seventies, led to the negotiation and signing of the first Great Lakes Water Quality Agreement in 1972 based largely on the Commission's recommendations. And this in turn led to reductions in the phosphorus content of household detergents and the beginnings of a massive expenditure on new and improved sewage treatment plants all around the Great Lakes.

The Great Lakes Water Quality Agreement of 1972.

AND ITS MORE COMPREHENSIVE SUCCESSOR SIGNED IN 1978, SPECIFICALLY RECOGNIZE THE GENERAL OBLIGATION OF BOTH PARTIES NOT TO POLLUTE ONE ANOTHER. IN EFFECT, THE AGREEMENT GOES ON TO DEFINE THAT OBLIGATION BY ESTABLISHING SPECIFIC WATER QUALITY OBJECTIVES. HOWEVER, THIS DE FACTO DEFINITION IS NOT STATIC. IT IS DYNAMIC. THE OBJECTIVES ARE MEANT TO BE REVIEWED AS FURTHER SCIENTIFIC DATA ARE PRODUCED. INDEED, THE 1978 VERSION OF THE AGREEMENT MADE SOME SIGNIFICANT CHANGES IN AND ADDITIONS TO THE 1972 OBJECTIVES, WITH PARTICULAR EMPHASIS ON THAT INSIDIOUS FORM OF POLLUTION, THE MAN-MADE CHEMICAL COMPOUNDS OR TOXIC SUBSTANCES, A GROWING NUMBER OF WHICH HAVE BEEN DETECTED IN THE FISH, WILDLIFE AND SEDIMENTS OF THE GREAT LAKES. THE 1978 AGREEMENT EVEN ADDED A PROVISION ADDRESSING DEPOSITION OF POLLUTANTS FROM THE AIR, A MARK OF OUR GROWING UNDERSTANDING OF AIR AS A MEDIUM OF TRANSPORT FOR POLLUTANTS WHOSE PRIMARY IMPACT IS FELT ON THE GROUND OR IN THE WATER. THE SIGNIFICANT POINT IS THAT THE GREAT LAKES AGREEMENT SOUGHT TO REFLECT THE BASIC OBLIGATION OF ARTICLE IV OF THE TREATY IN A FORM THAT WAS MEASURABLE AND ACHIEVABLE.

YOU WILL OBSERVE THAT THE SHIFT IN EMPHASIS IN THE 1978 AGREEMENT REFLECTED THE GROWING CONCERN ABOUT THE EFFECTS ON THE TOTAL ECOSYSTEM -- INCLUDING MAN AND HIS

HEALTH -- OF THE ENORMOUS INCREASE IN OUR USE, AND MIS-USE, OF CHEMICALS WHICH HAVE CHARACTERIZED SO MUCH OF OUR ECONOMY AND SOCIETY SINCE WORLD WAR II. RATHER THAN DEALING WITH POLLUTION WHICH COULD BE SEEN AND SMELLED AND WHICH CALLED OUT SO EVIDENTLY FOR REMEDIAL ACTION -- THE EFFLUENT FROM A PAPER MILL, THE SMOKE BELCHING FROM A STACK, THE OPEN GARBAGE DUMP -- WE ARE HAVING TO COPE WITH THE SIGNIFICANCE OF MINUTE QUANTITIES OF CERTAIN SUBSTANCES, SCARCELY DETECTABLE EXCEPT WITH VERY SOPHISTICATED ANALYTICAL EQUIPMENT, WIDELY DISPERSED AND VERY VERY PERSISTENT IN THE ENVIRONMENT, WITH LONG-TERM EFFECTS ON THE PHYSICAL ENVIRONMENT AND ON HUMAN HEALTH WHICH WE UNDERSTAND MOST INADEQUATELY. THE CAUSE-EFFECT RELATIONSHIP IS FRIGHTENING AND OFTEN UNCLEAR. THE DOSAGES WHICH CAUSE DAMAGE TO ORGANISMS ARE NOT PREDICTABLE. THE SYNERGISTIC EFFECTS WHEN THEY COMBINE ARE EVEN LESS SO. WE KNOW THAT SOME OF THEM CAN BE CARCINOGENIC OR MUTAGENIC, BUT WE DON'T KNOW PRECISELY WHEN AND HOW. WE HAVE TO DISCARD THE CONCEPT OF "SAFE" LEVELS OF POLLUTION WHERE THESE SUBSTANCES ARE CONCERNED. WE HAVE TO DEAL WITH A BALANCE OF EVIDENCE, AND TO CONTROL ACCORDING TO THE CONCEPT OF "ACCEPTABLE LEVELS OF RISK." WHAT IS NEEDED IS SOME BROADLY ACCEPTABLE MECHANISM FOR DEALING WITH THE CONCEPT OF RISK, INCLUDING THE ASSESSMENT OF ACCEPTABILITY, AND THE COSTS OF UNCERTAINTY.

IF THESE PROBLEMS, WHICH ARE CLEARLY GOING TO BE THE MAJOR ENVIRONMENTAL PROBLEMS FOR THE NEXT COUPLE OF DECADES, ARE EXTREMELY DIFFICULT ACROSS THE WHOLE RANGE OF THE PHYSICAL ENVIRONMENT, THEY BECOME ACUTELY SO WHEN WE DEAL WITH THE SUBJECT OF THIS CONFERENCE ON DRINKING WATER. THERE IS NO SUBSTITUTE PRODUCT FOR WATER, SO YOU CAN'T SWITCH TO ANOTHER. AND IF YOU DON'T THINK YOU LIKE WHAT COMES OUT OF THE TAP, YOU MAY NOT BE BETTER OFF WITH WHAT COMES OUT OF A BOTTLE.

IN 1982, IN ITS FIRST BIENNIAL REPORT ON THE GREAT LAKES WATER QUALITY AGREEMENT OF 1978, THE INTERNATIONAL JOINT COMMISSION URGED GOVERNMENTS AND OTHERS TO

> "FOSTER AND ENCOURAGE POLICIES, PROGRAMS AND INSTITUTIONS THAT:
>
> (A) HELP DEVELOP AND MAINTAIN A LONG-TERM ECOSYSTEM PERSPECTIVE ..... AND TO BE MORE ANTICIPATORY IN ITS ACTIONS;
>
> (B) ENCOURAGE RESEARCH, MONITORING AND ANALYSIS OF MAN'S IMPACT ON ECOSYSTEMS .....;

(C) HELP MAKE SCIENTIFIC AND TECHNICAL INFORMATION ABOUT MAN'S PLACE IN NATURE MORE ACCESSIBLE, UNDERSTANDABLE AND RELEVANT TO THE INDIVIDUAL CITIZEN;

(D) ENCOURAGE CITIZEN INVOLVEMENT IN IDENTIFYING AND SHAPING LONG-TERM ECOSYSTEM GOALS IN ORDER TO BUILD GREATER COMMUNITY CONSENSUS AND COMMITMENT."

I HOPE THAT IN THE NEXT TWO DAYS, AS YOU ADDRESS THE QUESTION OF DRINKING WATER, YOU TOO WILL KEEP THESE ADMONITIONS IN MIND, AND LOOK AT YOUR PROBLEMS IN THE PERSPECTIVE OF THE TOTAL ECOSYSTEM.

MR. PAUL EMERY

DIRECTOR, TORONTO WATER SUPPLY

WATER QUALITY CONSIDERATIONS METROPOLITAN TORONTO WATER SUPPLY SYSTEM

WATER QUALITY CONSIDERATIONS
METROPOLITAN TORONTO WATER SUPPLY SYSTEM

IN ONTARIO IN 1971, THE POSSIBILITY OF A PROBLEM FROM CONTAMINATION OF WATER SUPPLY SOURCES BY CHEMICALS AND METALS WAS JUST BEGINNING TO SURFACE WITH THE DISCOVERY OF LARGE AMOUNTS OF MERCURY IN FISH IN SOME AREAS. IN METROPOLITAN TORONTO WE DECIDED, AT THAT TIME, TO START TESTING THE WATER SUPPLY, BOTH THE SOURCE AND THE OUTPUT, FOR ALL SUBSTANCES WHICH MIGHT POSSIBLY BE OF CONCERN AS A CONTAMINANT.

ACCORDINGLY, WE ENGAGED AN OUTSIDE PROFESSIONAL COMMERCIAL LABORATORY TO CARRY OUT TESTS FOR PESTICIDES, INSECTICIDES, HERBICIDES, HEAVY METALS, AND OTHER POSSIBLE PROBLEM CONTAMINANTS SUCH AS VINYL CHLORIDE MANOMER OR MIREX. THIS WAS, OF COURSE, IN ADDITION TO THE TESTING FOR CERTAIN MINERALS CARRIED OUT IN OUR PLANT LABORATORIES ON A DAILY BASIS.

AS A RESULT, WHEN THE ORGANIC CONTAMINATION PROBLEM IN THE NEW ORLEANS WATER SUPPLY CAME TO LIGHT IN 1974 AND WE WERE IMMEDIATELY ASSAILED BY THE METROPOLITAN TORONTO MEDIA WITH A BARRAGE OF QUESTIONS ABOUT POSSIBLE SIMILAR CONTAMINATION IN THE METRO SYSTEM, WE WERE ABLE TO INDICATE, ON THE BASIS OF THREE YEARS OF TESTING, THAT NONE OF THE HAZARDOUS COMPOUNDS HAD BEEN DETECTED.

THIS MONITORING OF BOTH SOURCE AND OUTPUT OF THE METRO WATER SYSTEM HAS BEEN CONTINUED AND WE NOW HAVE 13 YEARS OF DATA AVAILABLE. OUR REQUIREMENTS OVER THE YEARS HAVE BEEN MODIFIED, HOWEVER, BY CHANGES IN INFORMATION ABOUT POSSIBLE CONTAMINANTS AS A RESULT OF RESEARCH, AND MORE PARTICULARLY BY MAJOR STRIDES IN THE SOPHISTICATION OF ANALYTICAL METHODS.

IT SEEMS THAT EVERY YEAR OR TWO THE MINIMUM DETECTION LIMITS OF MANY OF THE COMPOUNDS ARE FURTHER REDUCED. AS AN EXAMPLE, IN 1971 WE TESTED FOR ALDRIN WITH A MINIMUM LIMIT OF 0.02 ug/L, 20 PARTS PER TRILLION. IN THE RECENT TESTS, IN DECEMBER 1983, THE MINIMUM DETECTION LIMIT FOR ALDRIN WAS 0.001 ug/L, 1 PPT.

IN SOME AREAS, THIS SOPHISTICATION CAN BE CARRIED TO EXTREME LIMITS BUT AT CONSIDERABLE COST. FOR EXAMPLE, THE ONTARIO MINISTRY OF THE ENVIRONMENT, IN THE CASE OF DIOXIN, IS NOW TESTING TO A MINIMUM DETECTION LIMIT OF 10 ppq. TO PUT THIS IN PERSPECTIVE, 10 ppq EQUATES TO 6 ONE-HUNDREDTHS OF AN INCH OF TRAVEL ON THE 93,000,000 MILE JOURNEY FROM EARTH TO THE SUN.

AN IMPORTANT RESULT OF THE CONTINUING REDUCTION IN MINIMUM DETECTION LIMITS IS THAT MANY COMPOUNDS NEVER PREVIOUSLY FOUND IN THE WATER ARE NOW BEING DISCOVERED IN MINUTE QUANTITIES.

OUR PRESENT SPECIFICATION CALLS FOR TESTING AND MEASUREMENT, WHERE FOUND, OF 130 ORGANIC COMPOUNDS COMPRISING THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY PRIORITY POLLUTANTS LIST OF 97, PLUS PESTICIDES. WE ALSO TEST FOR 17 HEAVY METALS.

THERE HAS BEEN MUCH DISCUSSION LATELY WITH REGARD TO USE OF THE GRANULAR ACTIVATED CARBON FILTRATION PROCESS AND OF OZONATION AS AN ALTERNATIVE DISINFECTANT TO CHLORINE. MANY OF THE AGENCIES AND ARTICLES ON WATER QUALITY END UP WITH ADVICE FOR IMMEDIATE INSTALLATION OF THESE SYSTEMS BECAUSE, IN THEIR WORDS, WE ARE CONTINUING TO USE OUR ANTIQUATED SYSTEMS WHICH ARE NOT GEARED TO TODAYS WORLD, THAT WE ARE INDIFFERENT TO THE CONCERNS OF PUBLIC HEALTH AND THAT PRODDING BY OTHERS IS NECESSARY TO GET US TO DO OUR JOBS.

THE METROPOLITAN TORONTO WATER SUPPLY SYSTEM IS ABOUT AS MODERN AND "STATE-OF-THE-ART" AS ANY IN NORTH AMERICA. OUR NEWEST FILTRATION PLANTS, ONLY RECENTLY PLACED IN SERVICE, ARE DESIGNED FOR HIGH RATE DIRECT FILTRATION AND SOPHISTICATED PROCESS CONTROL. THE FILTRATION EFFICIENCY OF THE OLDER PLANTS IS BEING IMPROVED BY INTRODUCTION OF DUAL MEDIA OPERATION.

AS MEMBERS OF THE AMERICAN WATER WORKS ASSOCIATION, WE ARE KEPT INFORMED ABOUT WATER TREATMENT RESEARCH IN NORTH AMERICA AND WORLD WIDE AND CAN ASSESS ANY NEW DEVELOPMENTS IN RELATION TO OUR EXISTING SYSTEM. AS THE CANADIAN MEMBER OF THE AMERICAN WATER WORKS ASSOCIATION WATER UTILITY COUNCIL IT HAS BEEN MY PRIVILEGE TO MAINTAIN PERSONAL CONTACT WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY AND OF ITS ACTIVITIES THAT MAY IMPACT ON THE WATER TREATMENT PROCESS.

RESEARCH IS PRESENTLY PLANNED OR UNDER WAY TO DETERMINE WHETHER OR NOT EXISTING SYSTEMS OF COAGULATION AND FILTRATION CAN REMOVE MANY OF THE CONTAMINANT COMPOUNDS. THE RESULT OF SUCH RESEARCH WILL ASSIST IN DECISION REGARDING IMPLEMENTATION OF DIFFERENT TREATMENT PROCESSES.

IT HAS BEEN SUGGESTED THAT WE HAVE REJECTED THE IDEAS OF GRANULAR ACTIVATED CARBON FILTRATION AND OZONATION TREATMENT WITHOUT PROPER CONSIDERATION LET ME FIRST STATE THAT WE HAVE NOT REJECTED ANY PROVEN SYSTEM FOR WHICH WE CAN ESTABLISH A REASONABLE NEED.

BASED ON RECENT DATA FROM CINCINNATI, THE ACTIVATED CARBON SYSTEM ALONE WOULD COST $40,000,000.00 PER YEAR TO IMPLEMENT AND OPERATE IN METROPOLITAN TORONTO. OBVIOUSLY THE INSTALLATION OF SUCH SYSTEMS IS NOT CARRIED OUT ON A WHIM BUT ONLY AFTER SUITABLE EVALUATION OF ALL ASPECTS.

ONE OF THE PROBLEMS OF DISINFECTION WITH OZONE IS THE LACK OF RESIDUAL IN THE DISTRIBUTION SYSTEM. ACCORDINGLY, MOST SYSTEMS USING OZONE FOR TASTE, ODOUR AND COLOUR CONTROL ALSO USE CHLORINE FOR FINAL TREATMENT AND MANY ALSO PRECHLORINATE.

THE U.S. ENVIRONMENTAL PROTECTION AGENCY IN ITS COMPREHENSIVE PUBLICATION, "DRINKING WATER AND HEALTH" HAS INDICATED THAT ALL DISINFECTANTS MAY HAVE HAZARDOUS BY-PRODUCTS. MUCH RESEARCH WILL BE NECESSARY BEFORE THE POSSIBLE ILL EFFECTS OF OZIDES FORMED IN THE DISINFECTION PROCESS HAVE BEEN EVALUATED.

RECENT RESEARCH IN HOLLAND CONCLUDES THAT OZONATION CANNOT BE CONSIDERED A VIABLE ALTERNATIVE TO CHLORINE FROM THE POINT OF VIEW OF MUTAGENIC ACTIVITY.

THE PRIMARY REASON FOR SUGGESTION THAT OZONE TREATMENT REPLACE CHLORINATION IS TO REDUCE THE CONCENTRATION OF TOTAL TRIHALOMETHANES IN THE FINISHED WATER. HOWEVER, THE TRIHALOMETHANE LEVEL IN FINISHED METRO WATER VARIES FROM ABOUT 10 TO 19 PARTS PER BILLION WITH AN AVERAGE AROUND THE 14 MARK. THE MAXIMUM ACCEPTABLE CONCENTRATION IN CANADA IS 350 PARTS PER BILLION, TWENTY-FIVE TIMES GREATER THAN THAT AVERAGE. EVEN THE MOST STRINGENT OF STANDARDS, PROPOSED (BUT NOT YET ADOPTED) BY THE WORLD HEALTH ORGANIZATION, OF 30 ppb IS MORE THAN DOUBLE THE METRO AVERAGE.

FROM THE ABOVE, IT SHOULD BE OBVIOUS THAT OZONATION IS NOT NECESSARY IN THE METRO SYSTEM FOR TRIHALOMETHANE CONTROL.

IN THE MATTER OF GRANULAR ACTIVATED CARBON TREATMENT, WHICH I WILL CALL GAC, THERE ARE MANY QUESTIONS TO BE ANSWERED BEFORE WE CAN CONSIDER ITS INSTALLATION, NOT THE LEAST OF WHICH IS TO PROVE THE NEED.

IT IS NOT YET CLEARLY KNOWN HOW MANY OF THE ORGANIC COMPOUNDS PRESENT IN THE WATER SUPPLY WILL BE REMOVED BY GAC. AT THE MOMENT THE NUMBER PRESENT IS SMALL AND THE QUANTITIES ALMOST NEGLIGIBLE WHEN COMPARED TO ESTABLISHED MAXIMUM CONTAMINANT LEVELS.

THE ONTARIO MINISTRY OF THE ENVIRONMENT IS ABOUT TO START A RESEARCH INSTALLATION IN THE NIAGARA PENINSULA TO EVALUATE THE USE OF GAC. THE MINISTER, THE HONOURABLE ANDREW BRANDT, HAS INDICATED THAT THE RESEARCH AND EVALUATION WILL PROBABLY TAKE AT LEAST THREE YEARS.

IN CINCINNATI, OHIO, WHERE THE SOURCE FOR THE DRINKING WATER SYSTEM, THE OHIO RIVER, HAS BEEN ALLUDED TO AS A 'CHEMICAL INDUSTRY SEWER', THE CITY, WITH TECHNICAL EXPERTISE AND FINANCIAL ASSISTANCE FROM THE U.S. ENVIRONMENTAL PROTECTION AGENCY, CARRIED OUT A RESEARCH PROJECT ON GAC FILTRATION WHICH TOOK ALMOST FIVE YEARS.

HAVING STUDIED THE RESULTS OF THIS RESEARCH IN DETAIL, THE CITY HAS NOW EMBARKED ON INSTALLATION OF A NEW GAC FILTRATION PLANT TO REMOVE MUCH OF THE CONTAMINATION FROM THEIR RAW WATER. BY THE TIME THE PLANT IS BUILT AND IN SERVICE, 9 YEARS WILL HAVE PASSED.

FINALLY, WE COME TO PUBLIC PERCEPTION OF THE WATER SUPPLY AND A PROBLEM WHICH BOTHERS WATER WORKS MANAGERS FROM TIME TO TIME THESE DAYS. THERE SEEM TO BE A PREPONDERANCE OF ARTICLES ON WATER SUPPLY APPEARING IN ALL KINDS OF PUBLICATIONS. THERE WAS EVEN ONE A FEW MONTHS AGO IN THE REAL ESTATE NEWS.

FOR THE MOST PART THE WRITERS ARE RESEARCHERS WHO HAVE SPENT ABOUT TWO OR THREE MONTHS IN A LITERATURE SEARCH. THE ANNOYING PART IS THAT IN ALL THIS EXHAUSTIVE RESEARCH ON THE SUBJECT, THEY HAVE IN MOST CASES FAILED TO EVEN CONTACT THE WATER SUPPLY AUTHORITIES.

AS A RESULT, MANY INACCURATE STATEMENTS GET INTO PRINT WHILE DENIALS OR REBUTTALS ARE EITHER PAID LITTLE ATTENTION OR ARE ASSUMED TO BE A COVER UP.

MANY OF THE ARTICLES AND STATEMENTS END UP BY SUGGESTING OR ADVISING THE USE OF BOTTLED WATER. AS A RESULT, METROPOLITAN TORONTO, LAST YEAR, ARRANGED FOR THE DETAILED TESTING OF 14 SAMPLES OF BOTTLED WATER FROM ONTARIO, QUEBEC, SWEDEN, FRANCE, GERMANY AND ITALY TO THE SAME SPECIFICATION AS THE METRO SUPPLY.

SURPRISINGLY, WITH MINOR EXCEPTIONS, THE BOTTLED WATERS CONTAINED TRACE ORGANIC SUBSTANCES, OF THE SAME NATURE, NO MATTER WHAT THEIR SOURCE. HOWEVER, THE WATERS WERE, IN OUR OPINION, SATISFACTORY FROM A CONTAMINATION POINT OF VIEW. IF WE EXCLUDE TRIHALOMETHANES WHICH ARE ACTUALLY FORMED IN THE TREATMENT PROCESS, THE BOTTLED WATERS, IN EVERY CASE, CONTAINED MORE SUBSTANCES AND HIGHER CONCENTRATIONS OF THOSE SUBSTANCES THAN ARE FOUND IN THE TREATED WATER LEAVING THE METRO TORONTO FILTRATION PLANTS.

A FINAL SURPRISING FACT IS THAT TWO OF THE BOTTLED WATERS ARE, WE UNDERSTAND, SUBJECT TO GAC TREATMENT BUT THE FINISHED PRODUCT STILL CONTAINS THE SAME LOW LEVELS OF TRACE CONTAMINANTS.

PAUL M. EMERY, P. ENG.
DIRECTOR OF WATER SUPPLY
METROPOLITAN TORONTO

FEBRUARY 6, 1984

DR. ROSS HALL

PROFESSOR, BIOCHEMISTRY
MCMASTER UNIVERSITY

THE QUALITY OF EXISTING WATER SYSTEMS AND PUBLIC PERCEPTION

The Quality of Existing Water Systems and Public Perception

Dr. Ross Hall
Professor Biochemistry
McMaster University

Thank you! I wonder if I could have the screen, please. I want to show a few slides.

My service on the Canadian Environmental Advisory Council gave me an excellent opportunity to gain insight into the whole process of decision-making and the role of science in decision-making. And this is what I would like to address this morning. Just what is the scientific role in decision-making, and, in particular, decision-making as it relates to drinking water?

I wish to open my remarks with a balance between science and common sense because I think science can only take us so far, and then we have to start using common sense when it comes to decision-making. Let me look specifically at a branch of science in which a lot of decisions about the quality of water are made. Toxicology: what can the science of toxicology tell us and what information can it give us and what information it will **not** give us. Because we don't really understand what science can do, what it cannot do, we can use up a lot of time in arguments about quality and safety. So let me just address now the science of toxicology.

Toxicology is a laboratory science. It's a science in which experiments are done on a single chemical. A lot of chemicals that we know are in our drinking water have been tested under laboratory situations, eg. dioxin, PCB's, tri halo methanes and others. However, these chemicals are tested one at a time! In the laboratory, people study one chemical, for example dioxin by itself.

Secondly, in the laboratory, chemicals are studied in large quantities. This is the nature of the science. One has to use animals as the basic laboratory tool and one must inject or feed the animals roughly large amounts of these chemicals in order to detect an effect. Thus, we are dealing with a single chemical and we are dealing with a large quantity of that chemical under a laboratory situation, but that's not the real world! And when you are dealing with drinking water, you are dealing with the real world! And the real world is quite different from that experienced by a laboratory rat or a laboratory mouse. The real world consists of chemicals, very small quantities, but not just one chemical - a whole range of chemicals: a multi-toxicity, or a multi-exposure to chemicals. So, the real-world situation is different than that from the laboratory. So we are thus then faced with the problem of taking laboratory information and trying to extrapolate it into a real-world situation because we really can't do what you might call "real-world experiments." And this is one of the difficulties that science has at the present time.

Let me address this in a slightly different way. Mr. Emery mentioned the question of trace chemicals. And, certainly, if you look at a part per trillion in another way, it represents one nickel in the Canadian national debt, or it represents a drop of vermouth in a trainlod of gin.

Let's turn it around and look at a part per trillion from the perspective of a single cell in our body and use dioxin as an example. Cells appear to have a receptor for dioxin and when dioxin at a part per trillion is in your body, there are about 200 molecules of dioxin per cell.

So when we talk in the chemical sense that a part per trillion is a minute amount, just turn it around and think of your cells because a part per trillion is not a minute amount from their point of view. It represents a few hundred molecules. And we know in the case of dioxin that a few hundred molecules is sufficient to impact on a cell harmfully. So I think we have to start looking at these questions more from the point of view of the cell and try to understand the sort of basic biology of this.

Let me address some of the issues that laboratory toxicology can't tell us much about. There is the whole question of genetic toxicity: carcinogenesis, tetratogenesis, geriatogenesis, and mutagenesis. The three genecities. We are now dealing with what we might call "single-cell toxicity." Laboratory toxicology - your whole liver or a kidney is damaged or something doesn't function very well - that's the kind of thing that you can see at a laboratory level. But we are talking now about events that are at the level of a single cell in a human body, or in an animal. A chemical can impact and cause a toxic event, in a single cell, which then can lead to either cancer if you are an adult, tetratogenesis if you are a fetus, or mutagenesis in your germ cells which will be passed on to future generations. These are all single-cell events! And they only take one or two molecules - we don't know how many - we cannot dismiss this kind of toxicity. It is not laboratory toxicity, it is what's happening out in the real world.

Now here is another aspect of carcinogenesis. The question of multi-toxicity. Laboratories work with single chemicals. But the real world is multi-chemical exposure. We know in the case of carcinogenesis that often it takes a combination of certain chemicals, a foreign chemical, for example, can attack the DNA of a single cell and start a carcinogenic process. The carcinogenic process would stop there if another foreign chemical didn't come along, becoming a promoter. Groups of chemicals could combine and cause a single-cell event leading to carcinogenesis, mutagenesis or tetratogenesis. These are some of the real-world happenings at the level of the single cell. Although we know in general, these events happen, nobody can predict where you, I or any of your friends or relatives will be stricken by these events. That's something that science cannot yet do.

There are many other things that one has to consider. For example behavioral events. We know that some people are sensitive to trace amounts of chemicals and it changes their behavior. Maybe not in a way that's incapacitating but it could be annoying to the family. And there is a whole range of common degenerative diseases which can be impacted by the presence of chemicals in the body. The immune system of the body, for example. We have evidence that certain chemicals in trace amounts can lower one's immune response. That means you are more susceptible to something else; maybe you get more colds than usual; maybe you come down with the flu. It doesn't incapacitate you but it's annoying. And how do you know that isn't part of an ecological toxicity as was referred to earlier by Mr. Seaborn. You just can't... you have to start considering these kinds of impacts. The immune system is compromised in some way.

Or, coming back to the examples I have here on the slides, the foreign chemical might be something in your drinking water, the foreign chemical number two could be something you are eating. So it is these kinds of combinations that are very difficult to predict. Cancer is only one of many things that can result from exposure to toxic chemicals. But it receives a lot of publicity and the public is very concerned about it. Indeed, they should: one out of four Canadians comes down with cancer. I am not saying that toxic chemicals are the sole reason for cancer, certainly not. But it is part of the picture. We have to consider that a lot of other health problems result from exposure to toxic chemicals.

I just like to reiterate: laboratory toxicology is limited in predicting the final effects of toxic chemicals. Epidemology is limited also. Epidemology works in retrospect. A hundred years from now we will be able to look back to the 1980s and say, ah, yes, there were certain things in the environment that did this and did that. But should we want to wait a hundred years before making decisions? I don't think we do!

Now let me turn to another aspect: this is analysis. We can do analysis very well as Mr. Emery says. You can determine chemicals in parts per trillion now, it's remarkable what the analytical chemist can do. But analysis should be more than just chemistry. We should start also looking at the biological analysis. And I am certainly pleased about the work that has been done in the last few years in the Health Protection Branch on using the Ames Test. The Ames Test takes the whole water sample and integrates everything. The Ames Test and the mutagenicity test are only one of many things that can be done. But in terms of setting water quality standards, serious thought should be given to including biological tests. The real world is biological, not chemical.

There are actually three parts to analysis. First, it is a sample collection - where you collect the sample and what kind of sample you collect. Second, there is the actual analysis, and third, there is the interpretation. Many times the analytical data are published or presented in some way ignoring the sample collection, ignoring the interpretation. One has to look at all three aspects if the analytical data are to be used in setting water quality standards.

Finally, I would like to comment on what I call **Good Science:** good science doesn't try to provide all the answers. There is no way that science can provide all the answers. We have to have a balance between science and common sense, and should make clear what science can do and cannot do. Science can certainly help to define society's values but it should not be the sole criterion by any means.

Let me just conclude and repeat that science can tell us so much, and we have to be aware of how much it can tell us and don't expect it to do things it cannot do. You don't have to be a scientist, you don't have to be a chemist or a toxicologist, I think, to understand this. And no matter what your interest or background or profession is, I think you can get an appreciation of just how far the science of toxicology and biology can take us. And so without any idea of the precise effects of toxic chemicals upon the human population, we have to assume there are effects, and perhaps we should assume the worst case, and that as a society we should minimize the public exposure to toxic chemicals.

Thank you!

DR. KRISTIN SHANNON

CANADIAN TREND REPORT
MONTREAL, QUEBEC

Dr. Kristin Shannon
Canadian Trend Report
Montreal, Quebec

Thank you for your introduction, but I should warn you that many of the groups that we have worked with have demonstrated that they have the inalienable right to refuse good intelligence - so I don't want to take responsiblity for all the policy pronouncements of a lot of these organizations that my colleague here named!

It's a pleasure for me today to have an opportunity to report to you on some of our findings on the Canadian public's perception of environmental priorities. At Canadian Trend Report, we monitor daily the key issues that are driving public policy formation in a wide variety of regions across Canada. We monitor daily, for example, 13 categories ranging from government and politics to business and energy to the environment. Behind that, we monitor 132 topics ranging from budgets to alternative energy sources to air pollution. Behind that, we monitor 3,500 sub-topics which are cross-indexed by province and region on a daily basis.

As the largest independent think tank in Canada, devoted to assessing public policy change, we keep our comprehensive databank focused on public policy priorities. I would like to congratulate David Simpson and the organizers of this conference, it is timely. Water quality, as of two weeks ago, has emerged as the number one issue and symbol of environmental concern in Canada today. That's the first time we have recorded that measure. (That measure reflects a rolling average over a six-month period, so that's a relatively stable measure.)

I should warn you that my talk is about politics, not about "facts," or - I hesitate to use this expression - "reality!" I know that some of our speakers this morning were much more comfortable about realities than I am.

Our research at the Canadian Trend Report focuses on the perceptions of the public, not on any absolute measure of organic trace matters in drinking water. But it is those perceptions which will dictate sooner or later the resolution of these issues in the political realm. So what are the politicians hearing? Well, when we look at the top ten issues for Canadians over the last three years, we find that environmental health concerns, not aesthetics, have consistently made the top ten list. That's out of about 132 issue areas.

The current top ten is understandably dominated by concerns about short- and long-term unemployment, technological displacement, economic recovery, spelled with a question mark by the Canadian public, welfare and health. Despite the overwhelming concern with economic issues, environmental health concerns rank seventh. This is an impressive research finding because it negates a conventional argument that environmental concerns are a "frill" which may be easily driven out by economic or job-creation issues.

Let me just take a quick look at a few long-term trends in Canadian behavior to see why these environmental health concerns hold such a strong position so consistently. And, by the way, the environment category as a whole has held an impressive, steady five to six percent of the total national news window, while other big concerns such as national unity came and went. For four straight years in Canada, there has been an upward movement of environmental coverage in the Canadian press.

Environmental Ethic: Let me just point to two trends that are driving it: first, in Canada the environmental ethic runs very deep. Despite the Canadian public's preoccupation with the recession, Canadian Trend Report research detects no resultant erosion of environmental values. Environmental values appear in the news in such a pervasive manner that it's almost misleading to suggest that they are "just an issue or an item on the social agenda."

As CTR research has found, an environmental ethic has become part of the fundamental assumptions of Canadians as they plan their own behavior and evaluate that of their institutions. Attention to these environmental values comes from a moral perspective - one expecting decent behavior, especially when there is a likely effect on future generations.

Those efforts to talk about trade-offs such as jobs versus the environment or budgetary problems in introducing a new technology into a water management system, have persistently fallen flat because an option that is seen as requiring a sacrifice in environmental quality is automatically seen as, in the Canadian context, "morally wrong" and therefore unacceptable.

Our research shows, and this is an extremely important finding, that Canadians believe that they can have both managed development and a high quality of life. As a result, environmental responsibility is seen as a universal rather than as a proprietary set of issues to be left up to just certain activists groups or up to certain, however well-qualified government departments. In short, in Canada everyone feels the moral right to comment on drinking water.

In Canada, health risks are tied very closely to environmental issues.

Health Risks: The second trend of particular relevance is the increasing emphasis on the health consequences of environmental issues. Canadian Trend Report's health category, for example, has seen persistent growth, over the last four years, in attention to prevention of illness rather to after-the-fact treatment.

Accompanying this perception has come extended controversy over personal behavior such as smoking or environmental contaminants such as

PCBs that are seen as contributors to cancer and other illnesses. In particular, the word "recombinant" has a powerful message for the Canadian public. This linkage of health threats to environmental issues has upped the ante for the public, and if it has done so for the public it has done so for the politician. It has created demands for immediate remedial action, punitive regulation and for the application of the concept of "zero risk."

In the absence of reliable research or a consensus on acceptable levels of risk - and this is an extremely important finding when it comes to this issue of "facts" versus "reality" in the political arena, when the public doesn't believe it has research answers, it falls back on a conservative approach to hazard assessment, i.e. it tends to move towards zero risk. When the public feels underinformed on a subject, they also press for zero risk. When hazards are described in any one of the following four ways, public concern and attention to the issue is likely to persist. You may want to take note of this language because it will tell you very accurately how long an issue will be around.

First, if an issue is described as having "incalculable" consequences, if the risks and costs are seen as unknown and impossible to quantify with the existing data, then the issue is likely to stay with us for a long time.

Second, if it is considered to be "uncontrollable" from the perspective of immediate management options; if the management of the danger is perceived as uncertain or the technology of control is unavailable or too costly, for example, then you can expect a strong public and subsequent political reaction.

Third, if the risk is viewed as "inescapable," or, and here is the key word "involuntary," by individual action, when everyone is seen as potentially at risk, then it is a pervasive public issue and, of course, drinking water falls into this category.

Finally, if there is no timetable for recovery and damage is seen as long-term or permanent, when the only "cure" is seen as prevention of further damage - and the key word here is "irreversible" - then, again, it's a sensitive public issue.

If you listen to the words used by some of the people who have been engaged in managing this issue, talking about "acceptable levels of risk," you can understand now that this expression is jarring in the context of the trends and the language I have just outlined. Or listen to the words used by Ross Hall: "carcinogenic," "teratogenic," "mutagenic," "single-cell events" - that's the kind of language that strikes a particularly disturbing and reactive cord in the Canadian public.

When an environmental issue possesses all four characteristics (incalculable, uncontrollable, involuntary, irreversible) such as acid rain does, then it's going to be a politically long-lived concern. Water quality issues, especially drinking water, have this profile. That means that powerful symbolism is evoked for even relatively apolitical Canadians.

There is another set of reasons why politicians are paying more attention to environmental concerns these days. And I'd like you to think about this one for a minute. These reasons are tied to a growing political need to define a stable voting constituency in an era when traditional parties and their old ideological ties are weakening. The informal political process is often more influential nowadays than the formal party process. We are not voting for national parties, we are voting against incumbents in most elections these days. Within this informal polity, the environmental coalition is one of the most stable, one of the most politically mature, and it's also a training ground for other issue-based groups, which means the politicians pay particular attention to these concerns when they are not sure where to go for that consistent support in the general public. So do not expect politicians on environmental issues or water-quality issues to divide along traditional left/right party lines.

For the political perspective, content analysis, which is the system that we use, finds environment issues to have specific, well-defined characteristics that differentiate them from most other public concerns.

First, environmental issues have a long timespan. The language of the environment movement is notably coloured by words like "heritage," "posterity," "our children's children." Ad-hoc solutions, therefore, are disdained. What is sought is comprehensive, long-term policy aimed at establishing what has been called a conserver society by some in the Canadian environment.

A second characteristic of environmental issues, that sets them aside from some other shorter-term concerns, is that they are capable of attracting universal public involvement. In other words, when an environmental health issue hits the news, it tends to have nationwide pick-up and provokes comment from a wide range of people from across a broad socio economic strata. Unlike the situation with energy issues (except nuclear) nearly everyone feels competent to review policies and make judgments. In other words, from a politician's point of view, the environment is a middle-class issue with a very wide base of public support.

A third characteristic of environmental issues: pro-active attitudes. The public is ahead of policy-makers in its willingness to advance new, especially preventive environmental policies or technologies. In particular, the public regards most environmental departments as reactive, slow, unimaginative, and too oriented towards special economic interests. This can translate into support - suddenly, abruptly, in a very volatile situation, for strongly punitive regulation against lawbreakers or against people who are administrating systems if they are not being forthcoming with data.

There are also expectations in the Canadian environment of technology-forcing. In other words, Canadians feel that new protective technologies can and must be brought into play as quickly as possible. Again, the burden of public interest in this area is on the new, even if it's an experimental way to resolve something. So, even if a new system of carbon filtration would cost two-thirds of the budget in Toronto, the pressure will be there politically to adopt the system - even if you say, "but we don't know enough about it."

A fourth characteristic of environmental issues: there is an expectation of discontinuities and strong personal commitment. We find that people who are pushing these issues tend to believe that to get the results will require major personal and institutional adjustments. Also, the public demands a strong governmental presence, not so much to keep down costs but rather to ensure distribution of the inevitable effects fairly and to impose a predictable schedule. You hear a lot of discussion about "the schedule" in terms of water-quality concerns. For example, "1988 being too far off for many in terms of the recent settlement" in Niagara.

"Business as usual" is thought to have been a primary contributor to environmental problems. Therefore an overt, extraordinary commitment from institutions as well as changes from individuals are sought to remedy those problems.

Now that's a fairly sophisticated set of views for a political-issue based group and it implies great staying power when the politicians look at that group.

Then there is also the political question of new alliances providing enhanced support for environmental concerns. In addition to the politicians who are seeking stable, predictable political constituencies, there is - just to give you an example on the new alliances - more support from people who have been involved in health. Preventive health concerns were once outside the system. Now because of budget pressures, they are moving into the system. That means, in Cabinet, a different kind of discussion on an issue that would have been considered "environmental" five years ago than the kind of discussion you'll have today.

Another group that's come into these concerns more vigorously lately is labour. For several years, labour hasn't been able to deliver to its constituency any evidence of wage gains. And so they have stepped aside from some of their traditional wage issues, and gone heavily into non-wage issues such as occupational safety and health. In this arena, they have done extremely well with respect to their membership; and, the Canadian public considers it an appropriate thing for labour to do.

Another set of new constituents who are supporting the environmental agenda represent a set of economic interests. I'll just take one, for example: tourism. Provincial governments and businesses in Canada are really flogging the potential of tourism in the country to be job-creating over the long haul. In this context, the question of water quality is extremely important. That's another reason why it has become such a potent concern!

Let me take a quick look with you at some of the numbers that reflect the dramatic upsurge in concern over this issue which, by the way, we forecast accurately for the Department of Environment last fall. What the qualitative data shows is that water pollution now takes 21 **percent, one-fifth** of the total volume of concern about environment across the country. That means it is ranking as the number one environmental issue.

The principal public concerns are the toxic contaminants' suspected - **suspected** being a key word - effects on human health and the aquatic environment. While sewage treatment still receives a fair amount of coverage, usually in the summer months when bacterial proliferation is responsible for beach closings; it's, however, no longer the focal point in water-polluting issues. The issue considered to be by far the most urgent by the public is that of drinking water safety. So, environmental groups who are talking about this as an object for inclusion in a bill of environmental rights are timely in their concern.

Research findings which suggest that the action of acid rain, for example, on water pipes releases lead and may release aluminum into the drinking water are being widely reported. They mention the risks to human health from lead poisoning - "Alzheimer's Disease." This will likely heighten public demands for tougher policies against air-polluting industries.

Now the important thing about these stories, even when they say, "we are not sure yet," "this research is not exact," etc., etc., is that from a political perspective is that they bring the acid-rain issue and the drinking-water issue together.

About waste management, public fears here centre primarily on the leakage of toxics from industrial waste locations and landfills, contaminating surface water bodies, groundwater and, consequently, drinking water. Across the country, but especially in Ontario, "not-in- my-backyard" opposition to proposed hazardous waste disposal sites and landfills is largely fuelled by the threat of having a potential Love Canal in the neighbourhood.

Pollution in the Great Lakes and Niagara River water bodies remains the subject of prominent press treatment, reflecting the public's growing worry over toxic contaminants, in particular dioxin. For example, results of a recent opinion poll show that two-thirds of Canadians and 75 percent of Ontarians that it is extremely important to eliminate Great Lakes pollution. Public criticism is in part directed towards the lacking bilateral efforts to act on the Great Lakes Water Quality Agreement. While funding for clean-up programs is seen as one problem, another is perceived to be governmental reluctance - that's U.S. and Canadian - to give up or share jurisdictions in what until recently has been treated as a local matter. The public clearly feels that only combined efforts by all governmental levels on both sides of the border can combat water pollution on that scale.

Faced with two government departments arguing about a research finding - a "fact" FACT, you remember - the public, again, will head in the most conservative direction of accepting as a fact whatever version seems to be the most threatening; that is where they want to see action.

Reports on ecological damage such as the increasing number of fish developing cancer, to a degree that someone has characterized them as, "unfit even for consumption by rats," and suspected effects on human health only serve to intensify the issue. Already, according to Environment Canada's survey, the majority of Niagara area residents believe that drinking water from the Niagara River and Lake Ontario is a health hazard. The survey itself has drawn favourable press response, interestingly. It's seen as a reaction to pressure from local environmental groups and reportedly represents the first attempt by a government body to actually measure the depth of concern in Niagara. Well, it's not the first attempt, but it's one of the better-publicized attempts.

While clean-up programs are regarded as essential for the recuperation of damaged systems, public expectations increasingly include the need for prevention policies whereby strict pollution regulations reduce and, if possible, eliminate contamination from municipal and industrial sources.

These research findings suggest that municipal and provincial budgets will be strained over the next few years to meet the growing public concern about, especially, the quality of drinking water. This is a kind of good-news/bad-news joke for many of us here today during a time when competition for budgets is particularly keen. The good news is: Canadians are noticing their water and sewage infrastructure. The bad news is: the same thing!

It's clear from our research that this issue will also be tabled for the politicians in a dramatic way by the voting public in 1984. And as long as any of these four key characteristics evolve - "incalculable," "uncontrollable," "involuntary," "irreversible" - drinking water quality will not get off the urgent list.

Phrases such as "acceptable levels of risk," if there is uncertainty, will confront public pressure for zero risk. Phrases such as "balanced evidence" will only be heard by the public if an institution or a spokesman is seen to be taking an aggressive, pro-active stance on the issue of drinking water quality. Facts presented in a defensive posture simply will not register in the current political context.

So, good luck in your efforts to bring "fact," public "perception" and political "reality" into better balance.

UNEDITED TRANSCRIPTION

Question and Answer Period

My name is Trevor Hancock from the Department of Public Health, City of Toronto. In the spirit of facts presented in a defensive posture, I'd like to ask Mr. Emery if he would care to define "safe" in view of his quite unequivocal statement as to the safety of Toronto's drinking water. It's an important question because this is the issue that comes up time and again. What is meant by the word "safe"? Does it mean that there is not one single health consequence in the lifetime of any of the people drinking that water, and if not, what does it mean?

Paul Emery

I would define "safe" in that context, Mr. Hancock, as state-of-the-art safe. Historically, there have been new facts found every year that have changed people's perception of what is safe or what is right or what is wrong. And these facts then changed the perception of what's safe. The drinking water in Toronto is state-of-the-art safe and I would not try to answer the question you posed as to whether it might have a detrimental effect on one citizen in a hundred years or whatever. That is not the context in which I was giving the definition. Does that answer your question?

Trevor Hancock

Well, it does and it doesn't. You used the word "safe" in a public way, and I think what the public understands by safe and what you are now defining as safe are two very different things. And I think that if we are going to have a debate as to safety, we need to be clear what we mean by safe and to be clear that safe in the context that you have just defined does not mean without health effects or without possible health effects. And that's an important issue to get across.

Paul Emery

Let me say one thing, that if I were certain, I mean certain, from research or however, that a new method of treatment would definitely remove all organic contaminats from Lake Ontario water, I would be the first one to recommend its being put into Metropolitan Toronto. To answer the concerns that have just been expressed by our last speaker that the public would like zero risk: now the big factor here is it would have to be certain and others involved would have to be certain, it would do the job. And these are the things that are going on now as research to find that out. So I am not against the idea of zero risk. I am against the idea of doing something and then finding out that you still haven't achieved the zero-risk factor.

Comments: [beginning of comments not spoken into microphone, could not be deciphered] ...and I congratulate the organizers in getting such diversity of opinion. It will be quite stimulating to the audience. I don't have a question, but I have two or three comments I want to make primarily on Dr. Hall's talk which I listened to with great interest. As a professional toxicologist, I had difficulty with one or two of his descriptions of what toxicologists do. And since part of this conference might be construed as education of the different roles of different organizations in different disciplines, I like to just indicate that perhaps some of the things he suggested re slowly moving out and new things have been happening in the discipline. For instance, toxicologists do not just look at the effects of single chemicals - one at a time on animal population. The literature over the last five years, I think, indicates a dramatic increase in multi-chemical studies looking at the effects of several chemicals in combination. Also, there isn't just a perception of an impact of a chemical on liver or kidney. The science is now married to biochemistry and electron microscopy and pathology. And no toxicologist today approaches his discipline without looking at all those aspects. So the impact of a chemical on a cell itself is a critical event and is assessed very carefully in the new science of toxicology.

You mentioned in your slide the effects of binding of one molecule of dioxin to a cytosol. And I think that's a very good illustration for people in this audience and the public of how things work at the cell level. It might be useful to point out, however, that the entry of that bound dioxin molecule into the nucleus does not mean that that cell is then going to enter into a cancer phase. That event itself still requires the cancer-initation process because the coding in the DNA may not result in a cancer event in that cell. So, perhaps that's something that needs to be pointed out in further talks, Dr. Hall, when you are giving that illustration.

The last thing I am most interested in because it is an area of personal interest is in synergism, and we do look at the effects of multi-chemicals now. Interestingly enough, most of the studies that have been looking into that have found that synergism is not the problem that one expects it to be so far. Additivity is a concern. But in many cases we have more examples of subtractivity. Certainly, the approach through all the disciplines that I know in the area of dioxin research is to eliminate men's exposure to as much as it is possible to dioxins. But there is an interesting example of subtractivity in some cases where they stimulate metabolism of other compounds and their rate of excretion and lower toxicity to other compounds. So, perhaps, that's another perspective in balance that we need to add in to our discussion of synergism which is just about the only part that it is brought out in the news media that subtractivity and additivity are rarely mentioned.

And, finally, I was reading the other day the Canadian Atlas on Mortality, and it was interesting to read there that over the last several years, the cancer rate of individuals living around the Great Lake space - and especially Lake Ontaric - is lower than the national average. And perhaps that's an encouraging sing. Thank you!

Dr. Ross Hall

Well, I just appreciate the dialogue here. I wasn't talking about toxicologists. I was just talking about the science of toxicology and what the speaker said is quite true. The science is rapidly evolving and my own professional biochemistry is very much a part of that. However, I was looking at it more from the perspective of public policy and many of the things that are going on in the science are still a long way from providing us with the kinds of answers that we'd like to have in the public policy areas. I think the things I said about that aspect still stands. The science is evolving but there are still many things it cannot do, and it will be a long time before it can do things with precision.

As far as the dioxin slide is concerned, I think I tried to emphasize that we know that dioxin binds to a receptor in the cell but what happens thereafter is very fuzzy, and I certainly agree with the speaker that we just don't know what happens thereafter and the cell may or may not be damaged - we just don't have that kind of a precise information. But we know in general that dioxin at parts per trillion can be toxic.

As far as synergism is concerned, I would much rather look at it again not so much from the laboratory point of view where you have definitive mixtures of chemicals but look at it from the point of view what the real world is. And I think some experiments going on in your own department here with the... just looking at the... I repeat the Ames Test which is a multi-genecity test on drinking water. That to me is an interesting kind of an experiment because you don't worry what the chemicals are, you don't worry about synergism, you just see what the effect is, the integrate of effect. "The integrate of effect" I think is a better term than synergism because it is the final effect and that's really what the real world is - what is the final effect of the drinking water on your body. So rather than getting into a concern what synergism is - positive or negative or neutral - one should just look at the integrate of effect and always look at the total exposure. And some day, I'd like to see a laboratory model that includes the effects of drinking water, the effects of the food, the effects of chemicals on your skin - in other words, the total exposure which, again, I say is the real world with human beings. And another thing is that there is a laboratory model that takes into effect that human beings live for anywhere from 85 years - that's considered the biological lifespan of us all.

When you are dealing with laboratory animals where most of them live for 18 months or for a couple of years, it's not a very good model to relate to human experience. The laboratory world is somewhat removed from the human experience.

Jerry Ron,
Ontario Ministry of Environment

I'd like to return to the first question of Dr. Hancock. Now implicit in his question is that there is such a thing as "absolute safety." And I think it is very important to realize that the word as it is applied to drinking water is just not... cannot be interpreted in that fashion. There is so much data being generated, the analytical science has so far outreached all the medical knowledge in terms of the significance of the data that it would be a true fool who dare stand up and say, any particular trace chemical can be judged to have no potential of the fact over a specific period of time. So I think when people try to, in a simple manner - get a yes/no - it's foolhardy to perceive it in that fashion. I think Dr. Hall, when he had a slide showing the sampling, the analysis, the interpretation - how crucial all these stages are now in generating data and how easy it is to generate data containing errors if any of these steps are not very carefully scrutinized and controlled. So, consequently, while the science of analytical chemistry is producing numbers of extremely small concentrations, their real insignificance is out of reach currently of medical fraternity. So there is a tremendous gap in the toxicological implications of these substances. So when we say water, the Metro water is safe, based on existing Canadian guidelines - and everybody knows they need to be expanded, there are not enough of them - but based on what's there, it meets those requirements of a potable water supply. But by stating that, it places the spokesperson in this kind of defensive posture which was so well expounded by Dr. Shannon, so that if one dare say any supply is satisfactory based on existing Canadian standards, it's almost by inference that one is locked into some conspiracy. But that's the kind of miliey in which people working in this field must function.

I have one question for Dr. Hall. I was interested in the tumour slide and it indicated that 65 percent of fish in Lake Ontario, tht species, have that tumour. I have never seen that date. I would like to know how representative it is of a specific fish population and whether it has been published. Thank you!

Dr. Ross Hall

I may respond to the speaker's last question, to give you that specific answer. The data that I showed was obtained by Dr. Ron Sanstegard of McMaster University. The species is, I don't know why it is named like that, but it is the "White Sucker," which, as I understand the name applies, is a bottom fish. And I think it's a species that tends to inhabit - I am not absolutely certain, perhaps there is a fish biologist in the audience that could probably help me, provide more precise information - but I think it inhabits the... this particular group anyway, the western end of the Lake. Anyway, if you are interested I can tell you that I have a reference. Sanstegard has published his work in two or three papers and afterwards I can give you the information pretty well where those references are.

Joe Cotruvo, E.P.A.

I would like to congratulate Dr. Shannon on an I think truly outstanding articulation of the dynamics of public opinion and the powers that it can generate or perhaps overstate. And it's something that all of us deal with in one respect or another and I thought I add a few questions to some of the subjects that you discussed in the analysis that you have heard.

In our experience, there seems to be a very significant dividing line in public perception between those substances that would be considered natural and those that are considered synthetic. And by definition, of course, synthetic is bad and natural is good. I think we all appreciate that in fact. I mean the vast majority of "contaminants" are natural. However, the public doesn't respond to that. We have numerous cases - water supplies that are contaminated by natural arsenic or natural radionuclides - and the public in those areas is seemingly totally unmoved by that. I mean they are perfectly content to say, it's been there all these years, it can't possibly be a problem because it is natural. Did you ever ask that question, did you ever get a perception at least on how the public makes that distinction between good and bad, natural/unnatural? And then I have one more question.

Dr. Kristin Shannon

In Canada, let's take arsenic for example, the issue with arsenic is not so much that it is natural and, of course, in Canada the runoff from goldmines tends to produce this situation. But the effects are known. The risks are known. They are quantifiable. So, in other words, if in a particular community an article is published which says, if you go fishing on that river, you will swallow so much arsenic over the next two months. And very likely six people will die. That story may appear one time and then never be heardfrom again because people feel it's a manageable risk around something that's known and they can do something about it themselves. And besides, they know for sure that they belly-up if they go to that particular river.

If you say - let me give you another Canadian example: there is the outside possibility that someone's child sometime may possibly experience a touch of Reyes Syndrome around the question of spruce budworm spraying, that tory becomes a major national concern and eventually of course effects cross-border policies. It's the uncertainty factor that tends to bring out the conservative behavior on the part of the voting public, more than the natural versus synthetic issue at least on this side of the border. I think with Americans, you find the natural-versus-synthetic issue more clearly around the question of food than on the question of drinking water pollution.

Joe Cotruvo

How about in radionuclides? You know, we have water supplies that have very high amounts of radionuclides in them by any measure of relative risk and amounts that are considerably higher than let's say leakage from a nuclear power plant. And the perception is entirely different. Risks are relatively quantifiable, as well as unknown. It's still a matter of a lottery. It's still a matter of probabilities. But the perception of consuming water that has a lot of natural radium in it is entirely different from the possibility of a synthetic radioactivity release from somewhere. Did you ever get into that?

Dr. Kristin Shannon

There is a question of whether or not the public can visualize a responsible agent. Ontario Hydro is fond of struggling with these particular sets of issues. If someone falls off a telephone pole, again it's a personally undertaken risk. No one cares, and the corporation is not held responsible. But if there is a statement of a potential second- or third-generation risk from a transmission line passing over a particular farmer's cow, it's very hard to get that out of the data's. Again, the "natural sources" are not ones you can legislate against. So it's harder to form a group around a particular issue of that sort.

Joe Cotruvo

My final question: on the willingness-to-pay issue. In general, I am sure, everyone when asked would you be willing to pay more for greater safety, the answer is yes, in general. Have you done research on those cases where there is actually a decision to be made in a specific case where there was a cost to be levied upon consumers - increased rates or whatever - and what are the public willing to pay generally in those kinds of situations? Let's say if it's a matter of adding water treatment to avoid some relatively small risk potential.

Dr. Kristin Shannon

We are in a situation right now with most of our public budgets being under tremendous constraint. My attempt to summarize our research on your last question was the good news/bad news joke. The fact of the matter was that six years ago it was hard to get anyone interested in increasing a capital budget for changing the technology of a water treatment plant. The good news now is that people are interested. But now we don't have any money. And we are back to the bad-news side of that joke. I'd say the politicians are so serious about this concern now and it's one that will not go off their agenda in the next little while that it's good time, Mr. Emery, to go for some increases in those capital spending budgets.

Question: [no name given]
If I understand this correctly, Dr. Shannon's speech talked about the incalculable consequences of people being told that they are being involuntary exposed to the irreversible effects of chemicals in the water. Is that right? Because it's very important for me to know this because I write press releases and I want to get the vocabulary straight! I'm sorry I couldn't fit in "uncontrollable." I just didn't know where that comes in.

Dr. Kristin Shannon

If anyone of those four characteristics are seen to be present in an issue, the tendency of that public issue is to hang on unresolved.

Speaker: [no name given]

On a more serious note, I would like to ask you a question. In Canada, we are struggling now, we are asking the fundamental question; should Canada adopt a national drinking water act? In other words, should Canada define for all Canadians what drinking water is. I know in Quebec we have a proposed legislation on to define what drinking water is. Of course, the waterworks associations are pushing that because they know that they will be geting the other end of the contracts. If we go to carbon, if we go to very expensive water treatment - they will be getting the contracts to build the plants. But as far as I am an environmentalist, I am more concerned about the health... the moral issue of giving clean water to Canadians. Now the problem, of course, with the Canadian drinking water act is of course health. And water is a provincial jurisdiction. If you go back to the politics of the whole thing we see now, if you look at various standards where you look at the German standards for a certain chemical that are sometimes a hundred to a thousand times more stringent than the Canadian, than the American, than the French, then the British - how does the public perceive the variations of standards among world populations. Well, let's make it easier: among North American populations, or even among Canadian provinces, how can a Quebecker, how does a Quebecker feel when he knows that they let him drink more trihalomethanes in the water than a person living 30 miles west in Ontario? How would you think that would effect this?

Dr. Kristin Shannon

Well, In Saskatchewan it's obviously the fault of the CPR. In Quebec, it's obviously the fault of the Fed's. The simplest generalization I can make between the two countries, however, which keeps me from making this an issue for the MacDonald Commission, is that Canadians are more serious than Americans about environmental health issues from a political perspective. They are much closer to the land. You know, there is more wounded moose killed out season stories appearing in the Canadian press.

With respect to Quebed, Quebec has been the slowest, virtually, of all the major provinces to get involved in the environmental health concerns. But again, you have got politicians. I mean, there is Bourassa - he brought you the water; Levesque - he is paying for the water, etc. You have got politicians now who are hunting for new agenda items to capture the younger people in the province. And I think that's where I would look for an answer to your question.

Speaker: [no name given]

But do you think that Canada should adopt a nationwide standard? Or should we let the provinces adopt their own standards with the danger, of course, of having significant differences of what good water is in Montreal and what good water is in Regina?

Dr. Kristin Shannon

Mr. Chairman, I think this gentleman is trying to create another constitutional crisis here. I can't really comment on tht. He is trying to pull me into fact and reality rather than perceptions.

Speaker: [no name given]

I agree, it's gets difficult.

Peter Hack,
University of Alberta

A comment on one of Mr. Emery's comments. If I understood him correctly, I think he said that some of the Dutch work had shown that use of ozone did not give any reduction in mutogenecity. Some of the most recent Dutch work, which may not been published yet, does in fact indicate that it can reduce mutogenecity but it depends on where it is put into the process. If it is put early in the process, then it doesn't do anything; but if it's put later in the process, it is in fact able to reduce it.

Paul Emery

I was quoting from a paper published last November, at least I got the reference to it last November. Unfortunately, I left it out of my briefcase so I can't give you the reference.

Peter Hack

As I said, this may be unpublished as yet. It's fairly recent, I think.

Mayor John Penn
Town of Leamington

I'll keep it very short and simple. In every area today, we have people who need to get rid of toxic things like in the State of New York. Is there any thought of setting up simple depots where people can bring poisonous things and toxic sprays to dispose of them, so some responsible agency can dispose of them in a proper manner. Today, we flush medicines down the toilet. We get rid of sprays in the best way we know how. Containers are thrown to the landfill, and I think they create a lot of problems.

Paul Emery

Just in connection with that, sure there are a lot of moves of how to do that. The provincial governments and the municipalities are responsible for the disposal of waste. But, unfortunately, as Dr. Shannon said, the "not-in-my-backyard-syndrome" seems to be around everywhere. So you can't build one of these facilities because you have to go through an environmental assessment and the people that live in the area say, you can't have it here. We need it but you can't have it here. So the only place where we are going to put these things is on the moon.

Don Munt
Canadian Institute of International Affairs

I'd like to make some comments about the question that I see not having really been addressed here at this session, that is of public perceptions. As a social scientist, it never fails to interest me to watch, as we have seen earlier in this panel, the scientists who are real scientists, go at each other, arguing different methodologies, accusing each other of sometimes overgeneralization and so on. And I guess what I want to do is inject that sort of notes in the social-science side of these issues.

Well, I agree very much with Dr. Shannon's characterizations of the sorts of environmental issues that seem to have greater importance. The terms she was using of course were ones that somebody has already mentioned: incalculable, involuntary, irreversible, and so on. I would like to take issue with what I take to be a main assumption of her presentation. And that is that what comes up in the media analysis that she does and does she seem to be talking about mostly in her presentation necessarily reflects public perceptions. I think there are a number of ways in which that's an overgeneralization and, indeed, perhaps misleading. To assume that what you get out of reading the newspaper or doing an analysis of newspaper content in Canada is in any necessary way a reflection of public perceptions. Let me give just some very quick examples to which she might want to respond: some of the work that we have been doing recently suggests that press coverage has a substantial impact on short-term attention to issues in House of Commons, particularly in Question Period. It suggests, however, that press coverage has very little impact on long-term changes, that it has very little impact on what's going on within the bureaucracy in terms of policy development and implementation. And thus it has much less impact on what one might assume the kind of policies that are developed.

Another example, another problem I think in making the assumptions that she seems to do that press coverage reflects public perceptions would be to note that The Globe and Mail publisher, Roy Megarry, is continually interested in environmental issues to the point that The Globe and Mail has the only full-time correspondent on environmental issues, Michael Keat, and indeed sends him to conferences such as the present one.

I don't think that as much of a reflection that all of the people who buy The Globe and Mail, particularly those businessmen who buy it for the Report on Business, necessarily share Keat's, Megarry's or anyone's here concerns about environmental issues. And it certainly is not much of a reflection when The Globe and Mail increases their coverage on, for example, drinking water problems to assume that, first of all, newspapers such as those in Halifax - if indeed they can be called newspapers - are going to reflect the same coverage, and certainly that the public in such poorly-served cities as Halifax are necessarily going to get the same kinds of concerns that those who read The Globe and Mail and are interested in the problems that are covered there, would get.

Dr. Kristin Shannon

I am flattered as a social scientist that someone has a methodological point to pick with me that I hardly know where to begin. Let me just say that the gentleman and I have a first-premise problem. He said that press coverage reflects public perceptions is my first premise: it is not! My first premise is: press coverage is spotty, sloppy, inaccurate, opinionated, certainly non-factual and, no doubt, this will be misquoted!

But measures of line counts about certain issues do tell you something about the turbulence of particular issues. And that's one of the things that we are interested in measuring. The other thing is I feel I've got to make some comment about what is obviously his hidden first premise, i.e., that the silent majority counts for something in this country or in any political environment where there is a democracy. Our research suggests that it doesn't. It doesn't matter to us one bit if 80 percent of the people in the Toronto area are passively delighted with their drinking water. The fact that five percent are in annoyed with Mr. Emery's product will have, shall we say, disproportionate effect on his health and happiness. So, I am not in the business of counting the whims of the silent majority but rather keeping track of what the agenda setters are doing because, from a politician's point of view, they are the committed voters; they are the ones who go out and raise the money; you know, they are the ones that dictate the tone of Question Period, etc., etc. in the real political world where Mr. Emery lives. So I find myself in a situation not unlike Mr. Hall, talking about not the lab conditions but the real world in Toronto where five percent of the population may make Mr. Emery's life a little bit more difficult.

Don Munt

Can I just make one follow-up comment? Such a charming response begets no response at all. But I do feel that I might make a couple of points just in case they were missed.

The first would be that your characterization of my premise is not correct. That's not a very charming response to a response, and I apologize. But one of my arguments would be, however, that experienced politicians and the political process in general, not always, but in general, responds not just to media coverage that tends to go in blips and troughs, but to sustained evidence of public interest. If the public is genuinely concerned about problems, and there are other indicators of that, experienced politicians respond. Experienced politicians don't respond other than over the short term to what goes on in the media when there is a lack of additional evidence that the public concerns are there.

My other response would be, unless I misunderstood you, you said your primary approach was content analysis and you made a couple of references to the media and one reference that I recall to a public opinion survey. But I took it from your presentation that, in fact, virtually all of what you were saying was based on analysis of media coverage, and were simply suggesting that if water pollution problems or one sub-issue of the many that you look at are consistently number 7 or whatever they were in media coverage, that does not in any way lead to the claim that they are number 7 in terms of public issues or concerns of Canadians. I think one has to make a clear distinction between what's covered in the media and what Canadians are concerned about. My point was, I heard a lot that I assumed was based on media analysis but not very much that was based on actual data on public perceptions. That was my point.

Joanna Kidd
Pollution Probe

A quick answer for the Mayor of Leamington. We are here for these two days to talk about the consumer end of an environmental problem, most of us in this room, or all of us, being consumers of drinking water from one source or another. But it's tied into the source-end of it.

The mayor is worried about generation of toxic chemicals, especially small amounts. The Ontario Ministry of the Environment is currently conducting what they call the "Blueprint for Waste Management Process," which is an attempt to devise a comprehensive waste management strategy for Ontario, including toxical chemicals. Unfortunately, in that waste strategy, they are not considering small amounts of wastes. They are considering exemptions for the guy with 10 gallons of benzene or 15 gallons trichloracetylene. However, there is an answer. And in Pollution Probe's response to the Blueprint for Waste Management we gave the government a strategy, a practical strategy, of how to deal with these small quantities of waste that you and I and the drycleaner down the road generate. Thank you!

Ed Panko,
Chemics Incorporated

The question is to Mr. Emery. Three arguments were put forward for the non-use of GAC and the first one being we don't need it, and the second one being that it doesn't work, and the third one being that it costs too much. Of those three arguments, I wonder if Mr. Emery could give us what weight he would place on the arguments in terms of their relative proportion. Thank you!

Paul Emery

I think there is a misconception of what I said in relation to GAC. I said that the need is not yet proven. That is, GAC itself is not known yet to remove all the contaminants. As far as the cost factors are concerned, I have already indicated that were it certain that it would remove all contaminants from the Lake water that treats Metropolitan Toronto, I would be the first to recommend its installation in our system. I think that should answer your question.

MR. DAVID KIRKWOOD

DEPUTY MINISTER, HEALTH AND WELFARE CANADA

DEVELOPING AND MAINTAINING NATIONAL STANDARDS IN HEALTH AND DRINKING WATER

I am sorry, for your sake, that the Minister of National Health and Welfare was unable to accept the invitation to speak to you on this occasion. Mme Bégin combines a lively and entertaining style with the ability and willingness to tackle, directly and incisively, difficult and sometimes contentious issues of public policy. While her absence, therefore, is your loss, I must confess that it is my gain to be asked to replace her, and thus to have the pleasure of being with you today and the opportunity to participate, in a limited way, in your deliberations.

The theme suggested for Mme Bégin, had she been able to be here today, was that of "Developing and Maintaining National Standards in Health and Drinking Water". I propose to speak briefly on this subject, and then turn to some more general observations on issues relevant to the maintenance of reliable sources of drinking water of high quality.

As a preliminary point, let us recall that in our federal system (and I believe this is also true in the United States) environmental issues such as water and air quality give rise to particular difficulties in delineating clearly the respective roles of the various levels of government. To the extent that particular issues involved may be essentially local in character, jurisdiction and responsibility normally rest with provincial governments, which in turn may choose to delegate some of their authority to municipal levels. Within this frame of reference, the federal government, until the last few decades, has restricted its role to areas of explicit federal jurisdiction, such as international and inter-provincial transportation.

Thus in 1923 the Government of Canada moved to regulate the bacteriological quality of drinking water on vessels traversing inland waters, and subsequently extended this to cover all common carriers and also to coastal shipping. By the 1940's the Department of National Health and Welfare was using the U.S. Public Health Standards as the basis for its regulations, but in the 1960's the need was perceived for Drinking Water Standards responding more specifically to Canadian conditions and requirements. Accordingly the Canadian Drinking Water Standards and Objectives were developed, in collaboration with the Canadian Public Health Association, and published by Health and Welfare in 1968. For the reason indicated above, these standards had no mandatory application except as reflected in regulations issued in their respective jurisdiction by the federal and provincial governments, but there is no question of their value as guidelines for legislators and administrators at all levels, Roughly in the same time frame, moreover, in response to changing conditions and attitudes, the federal Government assumed a more active role in this general field through the establishment of the Department of the Environment and the enactment of such measures as the Canada Water Act and the Environmental Contaminants Act.

In 1974, the Department of National Health and Welfare established a Federal-Provincial Working Group for revising the drinking water standards. In addition to ten Provincial representatives, both the Departments of Health and Welfare and the Department of the Environment sent delegates to the "working group" meetings. At these meetings, local, provincial and national problems were debated and discussed. Such a mechanism ensured that the resulting "Guidelines for Canadian Drinking Water Quality" are truly representative of the interests and opinions of the provinces and yet provide a uniform set of guidelines.

In developing these new guidelines the 1968 Standards were critically re-examined in the light of new information. The recommended levels accordingly were either modified, changed, retained or discarded. Furthermore, new parameters, to a total of some 50, were considered and reviewed and some new levels were set. All of the parameters were briefly outlined in the 1978 Guidelines, while fuller description is available in a separate publication "Supporting Documentation - Guidelines for Canadian Drinking Water Quality - 1978".

In March 1981, a Federal-Provincial Discussion Group was convened to assess the need to revise the 1978 Guidelines; this action resulted from increasing concern over possible deterioration in the quality of Canada'a water supplies. The Discussion Group concluded that the existing guidelines for physical, microbiological and radiological parameters were generally adequate. The Discussion Group, however, recommended that re-evaluation of a number of inorganic substances should be undertaken, including lead, arsenic, asbestos and uranium.

Particular concern was expressed over the presence of large numbers of organic substances in drinking water. The Discussion Group felt that the guidelines for phenols, pesticides and trihalomethanes should be re-examined. The need to consider establishing guidelines for a variety of chlorinated organic compounds known to be environmental contaminants was also recognized.

In 1982 the Conference of Deputy Ministers of Health recognized the need to reconvene the Federal Provincial Working Group on Drinking Water to address these concerns. The newly constituted Working Group met in Ottawa for the first time on June 21-22, 1983, and is now examining about 15 organic contaminants of drinking water not now included in current guidelines. Moreover the list of pesticides is being updated and expanded to reflect current usage more accurately. During the past few years particular concern has been expressed about the quality of drinking water drawn from the Great Lakes.

Almost one-third of the Canadian and one-fifth of the U.S. population - in total, about 60 million people - directly or indirectly depend upon the Great Lakes System for their fresh water supply used for drinking, recreational and sanitation purposes. I can assure you that we in the Department of National Health and Welfare are concerned about the presence of toxic chemicals in the Great Lakes and in other sources of drinking water. Throughout the last decade, the Great Lakes Water Quality Board of the International Joint Commission has reported on more and more chemicals that have been detected in the Great Lakes at concentrations ranging from parts per million down to fractions of a part per trillion. More than 800 such chemicals have now been reported. The Department is collaborating with the Ontario Ministry of Environment to develop improved technology for removing chemicals from drinking water.

Beyond the particular problems of the Great Lakes basin, it has been estimated that one million tons of chemicals not subject to specific legal controls, are used annually to treat drinking water in Canada. At the same time, point-of-use devices to improve the taste and quality of drinking water are increasingly coming on the market; many of them are not adequately tested, or controlled under present legislation.

New Drinking Water Legislation

This and other concerns require that we examine closely our means to ensure that Canada's drinking water quality is safe and wholesome. I must stress that the limits prescribed in the 1978 Guidelines for Drinking Water Quality are not legally enforceable standards unless promulgated as such by the appropriate provincial or federal agency.

The present legal framework on matters relating to drinking water supplies in Canada is complex and fragmented. It may not be effective in assuring the safe quality of drinking water. While many other countries have enacted legislation in recent years, in Canada only the province of Québec is currently planning to introduce regulations for drinking water. In the United States, in contrast, a Safe Drinking Water Act was passed in 1974 providing federal authority to set standards, recognizing the States' responsibilities to enforce them and providing for measures if States do not do so, and providing for protection of underground sources of drinking water. This Act also requires that consumers be notified if their water fails to meet federal standards and provides authority for research, technical assistance, information and the training of personnel. Apart from the general provisions relating to public health in the Department of National Health and Welfare Act, specific powers do exist under the Food and Drugs Act (by definition, drinking water is a "food") but these have not been exercised because the enforcement powers are quite inappropriate for application to community water supplies.

In light of what I have said, it is clear that a case can be made for strengthening the capacity of government in Canada to ensure the quality and safety of drinking water supplies by the extension of existing statutory authority. One possibility, now being examined by officials in the federal departments most directly concerned but not yet addressed by Ministers, would be to follow the United States example and develop, in active consultation with the provinces, a Canada Safe Drinking Water Act. As the Government has not yet considered this possibility, it would clearly be imprudent for me to speculate on what such legislation, should it be brought forward, might contain. A number of officials in interested departments, some of whom are participating in this conference, have their own ideas, and I have no doubt they will be happy to indicate privately what they would like to see considered.

But such new legislation, should the decision be taken to seek it, will not in itself ensure the supply of clean, safe drinking water. The situation has many factors, but it is obvious - to take a single example - that the rapid increase in the number of potentially harmful chemicals being put to commercial and industrial use, and in the diversity of their applications, constitute a major component of the growing threat to the quality of our drinking water. Such activities, of course, are undertaken in pursuit of economic ends which may offer major benefits to our society, and there are substantial costs in foregoing those benefits or in developing alternative, non-contaminating ways of achieving them. Furthermore, it is often the case that the noxious side-effect of some newly developed material or process is discovered only after it has already been in use for sometime, and lasting damage has already resulted. So the problem has many aspects, and additional regulatory authority with respect to water quality, should it be found appropriate, would strengthen the means available for tackling it but would not provide a total solution.

It is precisely because of the complexity of the interrelated aspects of this matter that conferences such as this one are important if we are to ensure, for ourselves and our children, the continued availability of sufficient supplies of clean, safe water - that most vital of all the resources upon which not only our well-being and comfort but our very survival depend. The multi-disciplinary approach, the interchange of information, perceptions and concepts among those involved in all of the subjects' many aspects, are essential. I am happy to have had this opportunity to participate briefly in your work, and I extend my warmest good wishes for its fruitful continuation this afternoon and to-morrow. Thank you.

MR. ROBERT HARRIS

UNIVERSITY OF PRINCETON

PUBLIC INTEREST AND WATER. U.S. EXPERIENCE

"Public Interest and Water, U.S. Experience"

UNEDITED TRANSCRIPTION

Dr. Robert Harris,
Princeton, N.J.

Thank you very much! I am very delighted and pleased to be here to share with you some of my experiences with dealing with this issue over the past ten years in the United States. Along the way, I would like to not only give you an idea of some of those experiences and what the public interest community, namely, environmental groups that were very actively involved in this issue experienced, but also a sum of the technical aspects of the problem that we all grappled with and still are debating and arguing to this very day that will become central to the arguments, I am sure, here, particularly in dealing with the presence of organic chemicals, notably those that have the potential of causing cancer, in drinking water.

In the United States, the concept of "acceptable risk" that we heard this morning is very much alive and we are struggling with the tradeoff between the cost in increased treatment of water or increased treatment of waste materials discharged in the water, and the benefits in the context of the public health benefits and, of course, in view of the public perception of those benefits, costs and risks.

What I would like to is to divide my talk into two major sections. First of all, I would like to, very briefly, discuss the history of the passage and implementation of the Safe Drinking Water Act in the United States. And then I would like to use the regulation of chemical carcinogens in drinking water as a case example.

The Safe Drinking Water Act that passed Congress in 1974 was first introduced in Congress in 1970-1971. The Act was introduced largely because a public health service report, published in 1969, showed widespread deficiencies in drinking water treatment plants' ability to process and delivery safe drinking water to consumers, primarily in small communities across the United States, in addition to a number of other problems associated with not only waterborne diseases but with contamination associated with heavy metals and other nitrates and other contaminants in drinking water. However, this evidence was not sufficiently persuasive to cause Congress or the American public a great deal of anxiety. Presumably, a few stomach aches were more tolerable and less deserving of a national statute than were some of the environmental issues that were receiving widespread attention within the public and within the U.S. Congress in the early 1970s, preceding the first Earth Day extravaganza in 1970.

In 1974 however, a number of events occurred which changed both the public perception and - as you might well imagine - the perception of our legislators as to the seriousness of the drinking water problems. First, there were a series of three reports, which I was involved in, that were published on the safety of drinking water in consumer reports. There were studies which I participated in; they were preliminary epidemiologic studies on the link between high cancer rates in Louisiana and the source of drinking water. The Environmental Protection Agency, that same year, conducted studies on what is in drinking water in communities along the Mississippi River, notably in New Orleans, and issued that report in the latter part of 1974. About that same time, there was a report on national television aired by NBC on the link between the chlorination of drinking water and the production of chemical carcinogens. This followed publications earlier by researchers in the Netherlands that demonstrated by laboratory and other studies this link.

Then Congress, shortly after these disclosures, dusted off the Safe Drinking Water Act, "dusted off" is perhaps not the right term, but they had been discussing it, debating it, and marking it up during this period of time. But, nonetheless, in the waning days the Congress passed this Safe Drinking Water Act in its present form. And between the time that it was passed and President Ford signed it, the CBS aired a national documentary on the safety of drinking water which more or less guaranteed that President Ford would sign it. And I think without question, the issue of chemical carcinogens, organic chemicals in drinking water were central to the debates in 1974 and were a major reason why Congress passed the Safe Drinking Water Act in the form in which it was passed.

Just to mention a few of the points, a few of the strategies of the Safe Drinking Water Act to give you a flavour for its approach: very soon after passage of the Safe Drinking Water Act, the U.S. Environmental Protection Agency was and did promulgate interim primary drinking water regulations that were to be health-based, that were to be based primarily on existing public health service drinking water standards that up until this time were used exclusively by the federal Government for inter-state carriers and, in general, had been adopted by a number of states for regulating the quality of drinking water at the municipal level. The interim primary drinking water regulations did not deal with the carcinogen issue but deferred this to a later time. The Act also called for a study by the National Academy of Sciences, National Research Council, that would serve as the basis for revising these interim regulations and were supposed to provide the framework for E.P.A. setting health goals which would become the basis for the revised national drinking water standards.

These standards were to be based on the assumption of relatively clean sources. The strategy here is that we know that there is a range of water supplies from relatively clean ones to relatively polluted ones, and if we base our standards which are to take into account feasibility and cost, as they should, on the assumption that we are going to be getting very polluted water, then those standards are likely to be more permissive than if the standards are based on the assumption that the source water is relatively clean. And Congress meant that if the standards that were to be based on economic and technological feasibility assuming a relatively clean source, would be too stringent for those water supplies that had to rely on relatively polluted sources, then E.P.A. was to issue variances that would allow the standards to be violated in a sense but require that the municipalities achieve as low a contaminant level as economically, technologically feasible, given the source water.

In addition, another very important strategy - primarily because it was my idea - a very bad one in the view of almost every waterworks official in the United States I might add - was that in addition to numerical standards on contaminants there should be the option to set standards based on process technology. And what was meant by this, to give you two examples, is as follows. Let's take the example of viruses which we know - as a previous speaker indicated - can be and are present in drinking water sometimes in the absence of bacterial contamination because viruses tend to be more resistant to treatment, but yet viruses are extremely difficult to monitor for. And it will be very difficult for many water treatment plants, if not most, to routinely monitor for the presence of viruses. So setting a standard on viruses would have very little meaning because it couldn't be implemented in that sense.

However as some communities have done, very few, one can set surrogate standards, that is, that the treatment process should be such that, based on laboratory studies, we know if is process is followed, for example, disinfection by a certain method for a certain period of time, after coagulation and filtration using certain standards, that the virus concentration in the water will be below that value that we would like to see it below. Using a second example of chemical carcinogens, we heard this morning that they are large, maybe large in number, that the number of chemicals identified, organic chemicals identified in drinking water are several hundreds, close to a thousand in number; of which a very small percentage have been adequately characterized toxicologically. And for even those that have been characterized toxicologically it is very difficult to set numerical standards on a chemical-by-chemical basis because of, first, the difficulty of setting a number which everyone will agree to, and secondly, because of the synergistic and other interactive effects - negative, positive - that might be associated with these chemicals being present together. So that in such circumstances the U.S. E.P.A. could propose a treatment technology such as granular-activated carbon or its equivalent that would represent the best available control technology economically feasible for reducing the concentration of these myriad of chemicals that may be present in water supplies that are vulnerable to this kind of contamination. These are some of the major points and strategies that were incorporated in the Safe Drinking Water Act that I thought were important to bring out in the context of my discussion here, as well as the discussion that will follow on today's panel.

What I would like to do now is to go over the regulation of organics in water very briefly to give you some idea of how that is fared under the Safe Drinking Water Act and what some of the environmental groups, citizens groups and others try to achieve, or at least their public utterances on the issue and perhaps why they took the positions that they did. As I indicated, the U.S. E.P.A. did not include regulations on chemical carcinogens in the interim primary drinking water regulations that were proposed and then promulgated about a year later, shortly after the passage of the Act. They deferred this until more information could be accumulated which, in 1978, lead to the proposed Regulations on Trihalomethanes, the products of chlorination, and a treatment standard based on granular-activated carbon. These two standards were debated for the following year and in 1979, the T.H.M. standard of 100 parts per billion was promulgated and the G.A.C. requirement was not, primarily because the waterworks industry was unanimously opposed to the granular-activated carbon or any treatment requirement, and I might parenthetically add they were also opposed to the T.H.M. requirement but did not win those arguments.

The environmental community challenged the 100 parts per billion trihalomethane regulations, in part because of something I previously said and that is they appeared to us to represent a bad standard which communities even with very polluted sources, high organic matter in the source could need, and therefore if not the letter of the law, the spirit of the law, that relatively unpolluted, uncontaminated, low-organic content sources should be the basis for setting standards and for those few communities that had to deal with very polluted sources, a standard could be arrived at through the variance process.

Nonetheless, it was an important beginning that everyone agreed should be made, and the Safe Drinking Water Act was not meant to cause E.P.A. to finalize anything. It was to evolve as more information was gathered and certainly the E.P.A. has recognized this as has the National Academy, that as technology develops, as health-effects information develops, that these standards and others should be revised accordingly.

I would like to elaborate a bit more on the presence of organics in water. I would like to discuss some of the sources of these organic materials. I would like to discuss some of the health effects associated with the presence of organics, and then I would like to emphasize the dichotomy that exists or that is emerging in the United States between the quality of surface water in this regard, that is the presence of organic chemical, and the quality of groundwater that has been shown to be contaminated primarily by hazardous waste disposal activities, and in this context use a case example to illustrate some of not only the levels of contamination that will help illustrate this dichotomy but also to give you a flavour for some of the health risks associated with contaminated groundwater. If I could have the first slide please!

We could perhaps divide the contribution or the presence of organic chemical carcinogens into two categories: the products of chlorination which I mentioned before, and everything else, that is the presence of these chemicals associated with industrial sources run off from municipal, urban areas; pesticides from farming areas and so forth. The trihalomethanes has been the area that has received the most attention and the most research over the years. Of course, trihalomethanes are composed of these four chemicals, combinations of chlorine and bromine. Bromine can't arise from the presence of bromined iron which gets oxidized in the process of disinfection and enters then to the chemical reactions with organic matter in a similar way that chlorine does.

It's important perhaps to point out that a relatively small percentage of the mix of chemicals that result from chlorinating water can be accounted for by the trihalomethanes, perhaps 10 to 20 percent. The larger fraction - 80 to 90 percent - is largely uncharacterized although there has been research over the past few years in attempts to characterize the fraction. We know it's mutogenic in the Aims Test and other tests. I believe Joe Cotruvo from the E.P.A., who will be on the panel next, can correct me if I'm wrong that the only firm evidence for carcinogenicity of any of these compounds is the evidence on chloroform. The other three have been tested in short-term tests that indicate the potential for carcinogenicity, mutogenicity tests and short-term cancer tests.

Not only have these trihalomethanes in products of chlorination been a subject of analytical studies and laboratory studies over the past several years, but have also been the subject of epidemiologic studies that have been mentioned previously. There have been probably now more than 20 such studies, some of which have focused as much as possible specifically on the chlorination process in an effort to answer the question, does chlorination of water increase the cancer risk or not. Some of the preliminary ones, such as mine in Louisiana and in Ohio, looked at the diochotomy between surface water and ground water, that is, as a surrogate variable for contamination by these and other organic chemicals. I think the public-health community would be unanimous in agreeing that by the standards of proof that epidemiologists use, that the link has not been proven. I tend to believe that the evidence is fairly strong, however, that there is an increased risk. An increased risk has been demonstrated by the proponderance of the evidence that chlorination of drinking water does increase the risk of cancer.

If you do a worse-case analysis of these data, just to give you a flavour for the magnitude of the risk and assume that the positive studies are correct, accurate and true, it would suggest that drinking chlorinated water where the trihalomethanes were in the vicinity of the E.P.A. standard - 100 parts per billion, slightly less actually - that the lifetime cancer risk would be approximately 1 in 1000, which would mean that for a city where chlorinated drinking water has been served for many decades that perhaps as much as four percent of the total cancer rate could be accounted for by chlorination of the drinking water. The sights that tend to show up as most significant in their association with chlorination: recto-cancer, colon cancer, and bladder cancer, in that order.

The concern for the other chemicals that are present and have been identified in drinking water throughout the United States has resulted from the phenomenal growth in the organic chemical industry in the United States after the Second World War. Beginning in about 1950, the production of synthetic organic chemicals increased dramatically from less than a few billion pounds per year to well over 300 billion pounds today. This has lead to in cities such as New Orleans and Cincinnati, Philadelphia on fairly industrialized rivers to the presence of literally hundreds of synthetic organic chemicals, generally present in concentrations below 10 parts per billion and usually present, in the vast majority present, in concentrations less than 1 part per billion.

However, we remember that we don't know very much about what the mixture means. We also remember that perhaps less than 20 percent have been tested for carcinogenicity. And we also can't forget what has been mentioned previously and that is some of these carcinogens are very, very potent in comparison to others. This is the scale of carcinogenic potency based on that amount of chemical that causes half the animals to get cancer, just to give you an idea of this tremendous range! There is about a billion-fold range between the potency of the least potent chemical carcinogen - saccharine down at the bottom - and the most potent chemical carcinogen that has been tested by the U.S. Government - dioxin, TCDT. Many of the chemicals that are shown the chlorinated ones to cause cancer like chloroform, trichlorethylene are far more down here. But I think the point to be made is that we cannot deal in terms of parts per trillion, parts per billion or for that matter concentrations, because we have to be concerned about the possibility that within this mix, we may may have extraordinary range of potency which has to be taken into account.

The concentrations of these chemicals in surface water, as I indicated, are typically below 10 parts per billion and often 1 part per billion, which brings me to the subject of the quality of groundwater in those areas subject to contamination. We have experienced in the United States, over the past three or four years, what appears to be an acceleration in the contamination of both public and private wells. There have been hundreds of wells that have been closed by local public health authorities because of this contamination. This is an example here of one well in Jackson Township, New Jersey. Jackson Township is important not only as an example of a groundwater contamination episode but also because a court case has recently been resolved and the award was 18 million dollars, awarded to the plaintiffs, about 100 families, whose wells were contaminated, against Jackson Township, the municipality that owned the municipal dump. You can see that in comparison to the concentrations that we typically find of things like thioene, methylene chloride, acetone, acetone benzene, trichloethylene, benzene, chloroform and so on - except for chloroform, these concentrations are in most cases, in comparison to the 10 parts per billion or less than 1 parts per billion in surface water, hundreds to thousands of times greater.

This would suggest that perhaps the contaminated groundwater may represent hundreds or thousands of times a greater risk. Certainly where we have seen groundwater contaminated, we have seen concentrations that are within this range or greater. So where we attempted over the past ten years to think of contaminated surface water in terms of chronic effects, we are now beginning to think about contaminated groundwater in terms of acute effects or sub-chronic effects in addition to chronic effects.

Let me give you one example that will illustrate what can happen, what has happened in one groundwater contamination episode in our country. In a rural area of Tennessee, in Hartimont County, there is a dump site that began receiving waste from the Welsocol Chemical Company in 1964. The method of disposal was the so-called time-honoured tradition of digging holes in the ground and dumping the waste in and covering them over again. The dump site looks like a golf course now, this being a fair way, where the contamination, the chemicals have been discharged into shallow trenches about 15 feet deep, covered over, capped and planted in grass. And although earlier studies suggested the groundwater was moving in this direction, later studies found that these studies, earlier studies, were in error and that, in fact, groundwater was moving in this direction, northwest towards the homes located along this road.

As a result, a myriad of chemicals, but relatively small in numbers in comparison to the list of chemicals that we might find in New Orelans' drinking water or in Cincinnati's drinking water or in surface water supplies that are subject to pollution, was found. And most of the contaminants present or present in relatively small concentrations in comparison to a couple, namely carbon tetrachloride, were the highest concentration that anyone is known to have been exposed to, is 18,700 parts per billion. It was practically a national scandal when carbon tochochloride was identified in Cincinnati's drinking water in the neighbourhood of 50 parts per billion. A number of years ago, chloroform was present in about one-tenth of this concentration, about 80, 90 parts per billion, thochochloroethylene was also present in fairly high concentrations in some wells, and most of the others - benzene, and the intermediate syntheses of some pesticides - chloradene, heptachlor - were present in relatively small conentrations although these chemicals tend to be more potent than these two.

There were a couple of three health studies: one conducted by the University of Cincinnati about the period of time that the residents were abandoning their water supply because the E.P.A. and the State had suggested they do so; and then later a study by a scientist from the University of Vanderbilt, University of Vanderbilt Medical School, a clinial examination of individuals. The earlier 1978 study which did have controls suggested abnormal liver function tests and enlarged livers in the population that after the exposure was reduced, tended to be reduced, that is, there were negative anormal liver function tests several months after exposure was removed. However, later studies of the population found them to be rather ill, although the deficiencies in these studies were that there were no control populations that were studied. Nonetheless, some surprising results, particularly in eye damage - I am told by those who investigated the individuals that optic atrophy is very rare in populations, particularly in both eyes, it was about 11 percent in this population. And for those of you who know the occupational history of carbon tetrachloride know that it has been linked in those occupationally exposed to carbon tetrachloride.

Furthermore, the comparison of the exposure and a risk assessment would suggest the possibility of these observations, that indivduals in fact were damaged in the short run by exposures at these concentrations. An exposure estimant which included both skin absorption and ingestion through formula suggested that the daily maximum exposure in the last year to which individuals were exposed exceeded the exposure which resulted the minimum effect of exposure which resulted in liver damage in guinea pigs, that the adult exposure was somewhat less. The very interesting part of this exposure, however, was that samples were taken in showers and found that the carbon tetrachloride, chloroform and other volatile organics readily outgassed into the indoor environment and that the calculated exposure and the exposure that was estimated from actual samples taken in showers suggested that the inhalation exposure from the carbon tetrachloride in the chloroform was about half the total exposure, or at least approached half of the total exposure in this particular calculation less than half. But, nonetheless, it was significant! This did not include inhalation exposure associated with the use of the water in the kitchen, in humidifiers or elsewhere in the home where the outgassing of these chemicals is possible. It also suggests that perhaps when considering that the toxicity of certain compounds is quite different when the exposure is inhalation versus ingestion; that we should not ignore in our standard-setting process the possibility that volatile organic chemicals not only are ingested in drinking water but also are breathed as a result of the non-consumptive uses, human consumptive uses of the water in the home. Incidentally, the comparison of accumulative exposure calculated in this population over the four/five years during which they were exposed to the accumulative exposure in the laboratory animals during one of the first animal cancer tests also suggests that the chronic risks, namely, the cancer risks associated with the exposure, also was quite high - 40 percent liver tumours in mice, for accumulative exposure of 1200 milligrams per kilogram body weight compared to the cumulative exposure of adults in this population which was about 284 - uncomfortably close to the cumulative exposure of the laboratory animals, there is not much extrapolation to be done here.

So in conclusion, the citizens' and environmental groups in the United States like the Canadian citizens' and environmental groups have been and are concerned with the quality of their drinking water. They are because of some of the studies, some of those I have mentioned here today, and others have increased our knowledge of what is in drinking water and what the possible adverse effects might be. This concern lead, ten years ago, to our passage of the Safe Drinking Water Act, which was the first national legislation to regulate drinking water in this country. But this was followed by persistent and widespread opposition and resistance by the waterworks community to regulation under the Act, to the promulgation of standards and to the implementation of the Act in general. The resistance was that the community did not believe that the cost associated with improving treatment would be matched or exceeded by the benefits.

However, the American public has continued to - as apparently the Canadian public does - view this very seriously and they have voted with their dollars as they have appeared they have voted here in this country. The sales of water treatment devices and bottled water has continued to grow in the United States. It's a multi-million dollar business.

Recently, the groundwater problem has raised its ugly head - so to speak. We are now seeing that groundwater is seriously contaminated in many parts of the country, that it gives new urgency to the setting of standards under the Safe Drinking Water Act for chemical carcinogens. It makes the process of regulation that much more difficult because not only are community water supplies involved but private water supplies are involved as well which do not fall under the jurisdiction of the Safe Drinking Water Act.

The health risks, I believe, associated with the groundwater contamination is much greater than the health risk associated with the surface water contamination.

As a final thought: if my biases have not either already been known to you or evident from my talk, it is generally been my impression - and I believe the impression of the environmental groups that have worked on this issue in the United States over the past ten years - that the health risks are serious enough to warrant improvements in water treatment practice and waste disposal practices in the United States. That what we have attempted to do - benefit/cost analysis - that we see that the cost associated with things like granular-activated carbon or changes in the disinfection process to reduce the trihalomethanes and other chemicals are more than offset by the benefits. I hope that you will pursue the same studies here and that the wants and desires of the citizens in Canada will have an important and overriding bearing on the direction that you take, the waterworks community, and legislators in tackling this very important problem. Thank you!

UNEDITED TRANSCRIPTION

Question and Answer Period

Sam Kline,
Kline Engineering Limited

First of all, I want to thank Dr. Harris for a very informative talk and perhaps - I want to introduce myself: my name is Sam Kline, I am president of a company called Kline Engineering Limited and we specialize in water purification systems that pertain to microbiological acivity combined with activated carbon. One of the problems that do not concern us to a certain extent is whether or not drinking water is safe. We are basically engineers and as applied scientists, we accept the verdict of the doctors and toxicologists, epidemiologists, and if there is any doubt at all in our mind that there is a possibility of water being contaminated by toxic or carcinogenic substances, our basic philosophy is: when in doubt, take it out! Now, from a practical point of view, and I think this is where Dr. Harris has made a very meaningful contribution. That is, the design, the operation of the water purification treatment plants have to be able to perform that function. And unfortunately, due to the history of the development of water purification, which goes back about a hundred years, the existing water treatment plants are out of date. They have to be updated! Not only from a point of view of removing the harmful substances but also from the point of view of reducing the health and welfare bill. The highest single item in federal and provincial governments is health and welfare. For discussion purposes, if we assume that about 25 percent of all diseases and illnesses in the country is created by polluted water. That being the case, if we only reduce the illnesses and diseases by 10 percent, we are talking about billions and billions of dollars that are saved annually by the governments. And that being the case, anything that is being done to eliminate organic contamination such as toxic substances, carcinogens, radionuclides, etc. should be encouraged.

Now we don't want to get involved in whether or not one particular chemical or one particular organic substance is more dangerous than another. The inherent operating characteristics of the plant should be such that it eliminates these pollutants. Let me give you two examples that are very important. Let us assume a deranged person or a terrorist would contaminate our drinking water supply, we have absolutely no protection. It would take a chemical analysis to be sent to a laboratory, probably at a state or a provincial capital, it would take about maybe six weeks to three months to get the result back. How would we become aware of it? And the answer is: by the hospitals being filled up. And, therefore, the existing water treatment idustry should incorporate systems that can prevent these disasters from occurring. Now, so far I have given you bad news.

So let me give you some good news. When we started our research back in 1970 on the elimination of these organic contaminants, including microorganisms and in viruses in particular, we did our own survey of water treatment plants that included Toronto, Hamilton, Montreal, Ottawa, one of the suburbs in the city of Montreal. And we discovered that those plants that had the highest degree of microbiological activity in their purification process were the ones producing the cleanest amount of water. When combining this particular characteristic with the use of activated granular carbon in water treatment, we came to the conclusion that this would be the ideal way of solving this organic contamination problem. Well, I have to tell you that for the last 14 years, we tried our darnest to do it. And we have some good news. We have a private plant that's been in operation in the Ottawa area for about 18 months. And we have succeeded in designing an aerobic, non-carcinogenic, microbiological treatment plant combined with activated carbon. And not only that; we have also discovered a way of using activated carbon to the point where we can desorb it or reactivate it for less than the cost of buying new activated carbon or putting it in the furnace. We can actually desorb it in place. The sum total of this, what it boils down to is that we can now build and operate water treatment plants at a total cost per million gallons that is less than the conventional water treatment plant. So what's wrong with it? Well, there is nothing wrong with it, except who is against motherhood. And this is our problem! How do we convince the Ministry of Environment, the people in Health and Welfare, and the municipal governments or the state governments who have direct control of your drinking water to jump on the bandwagon? And the water treatment industry is very conservative. But if we take the approach, an ounce of prevention is worth a pound of cure if you lick the problem. Thank you very much!

MR. ROY HICKMAN

DIRECTOR, BUREAU OF CHEMICAL HAZARDS
HEALTH PROTECTION BRANCH

HAZARDS IN DRINKING WATER

Panel:
Hazards in Drinking Water

Mr. Roy Hickman
Health Protection Branch

My task is to set the scene for discussions later today on the topic for this session; namely, "Hazards in Drinking Water". I will briefly discuss how and why our drinking water supplies contain chemical substances, the significance of drinking water as a vehicle whereby Canadians become exposed to toxic substances and I will conclude my remarks with some observations on those segments of the population that would appear to be at highest risk from chemical contamination in their drinking water supplies.

Figure 1 is a diagramatic representation of the hydrologic cycle. As water passes through the various phases of the hydrologic cycle, it carries and dissolves many other substances with it. Even in the clouds, water vapour becomes contaminated with gases, vapours and particulate material in the atmosphere as a result of air pollution. This phenomenon has recently attracted a great deal of attention because of "acid rain" but many substances, including traces of pesticides, PAH's and other volatile organic substances, are present in precipitation as well as the better known inorganic acidic substances. At the surface, some of the precipitation infiltrates and percolates through soils and rocks carrying minerals such as calcium and fluorides into groundwater aquifers. The remainder is surface runoff, visible as streams, rivers and lakes, that may dissolve substances from the overlying rocks, or from sediments present in these water bodies.

Therefore, even in the pristine conditions of nature before human intervention, water supplies taken from surface supplies or from underground sources inevitably have a certain content of a large number of chemical substances. These are referred to as "naturally-occurring substances" in Table 1.

In addition to the naturally-occurring substances, the quality of raw water sources is influenced by anthropogenic activities. Some of these are found in point source discharges and, therefore, amenable to control through effluent regulations albeit at cost. Other substances enter water through processes such as run-off and fall-out. It is of interest to note that these diffuse sources may contribute up to half of the total pollution load, according to OECD surveys. The difficulty in dealing with such sources through environmental protection strategies is illustrated by one or two examples:- Over one-quarter of the world's zinc consumption (which also often contains significant amounts of cadmium) is used for galvanizing which erodes and is gradually washed off in the weathering process. Salt used extensively in cold countries in order to prevent icing of roads

Figure 1.
The Hydrologic Cycle.

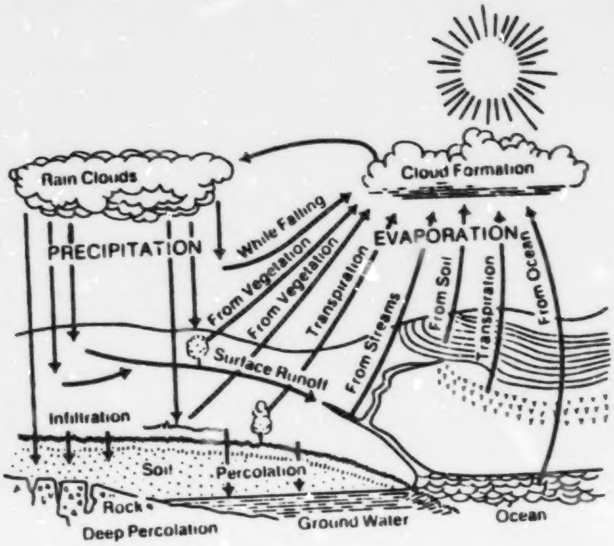

Rain Clouds
Cloud Formation
PRECIPITATION
While Falling
From Vegetation
From Vegetation
Transpiration
EVAPORATION
From Streams
From Soil
Transpiration
From Ocean
Surface Runoff
Infiltration
Soil
Percolation
Rock
Deep Percolation
Ground Water
Ocean

TABLE 1

Origins of Chemicals Commonly Occurring in Drinking Water

A. Substances affecting the source quality (raw water)

- "Naturally-occurring" substances
    - leached from geological formations (e.g., calcium, heavy metals)
    - derived from soils and sediments (e.g., humic substances)
- Pollutants derived from point sources
    - domestic sewage treatment (e.g., NTA)
    - industrial effluents (e.g., synthetic organics, metals, cyanide)
    - landfill waste disposal (e.g., metals, synthetic organics)
- Pollutants derived from non-point sources
    - agricultural run-off (e.g., fertilizers, pesticides)
    - urban run-off (e.g., salt, PAH's)
    - atmospheric fall-out (e.g., PAH's, chlorinated organics, heavy metals)

B. Substances resulting from treatment

- Substances formed during disinfection (e.g., trihalomethanes, chlorophenols)
- Treatment chemicals (e.g., chloramines, fluorides) and their impurities (e.g., acrylamide monomer, carbon tetrachloride)

C. Substances arising from the distribution and service systems

- Contaminants arising from contact with constructional materials and protective coatings (e.g., lead, vinyl chloride monomer and asbestos fibres from piping, cadmium from fittings, PAH's from coal tar linings)
- Substances arising from point-of-use devices (e.g., sodium, silver)

and highways can add significantly to the chloride concentrations in waters at the time of the spring thaw and acidic air pollutants, mostly generated in urban areas, may hasten corrosion and lead to secondary pollution. In rural areas, pesticides and fertilizers may impact on surface and groundwater quality. For example, rapidly rising nitrate levels in aquifers in parts of New Zealand have been linked to increased applications of nitrogen fertilizers and irrigation of horticultural and crop land. Similar problems have been observed in many other countries and infantile methaemoglobinaemia, resulting in deaths in about 8% of affected children, has been associated with areas in which high nitrate concentrations are present in the drinking water.

The second group of substances commonly present in drinking water supplies are those resulting from treatment at the waterworks (Table 1). Because of the recognized problems of contamination of water sources, most surface water sources and some groundwater sources receive some form of treatment prior to their distribution to consumers. Traditionally, such treatment has been applied primarily to reduce the possibility of spreading water-borne pathogenic bacteria and to reduce the content of suspended materials.

In the past decade, a major area of health concern has been the realization that compounds generated in drinking water during treatment may present health hazards.

Chlorine is used widely as a disinfectant and as an oxidant to degrade organic substances and ammonia. It is cheap and convenient to use. In 1974, Rook published his classic paper in which he showed trihalomethanes at significant levels following chlorination at the Rotterdam water utility.

Subsequently, the U.S. National Cancer Institute announced in 1976 that chloroform (the predominant THM in most water supplies) is carcinogenic in both rats and mice. Gradually, in the intervening period, it has been realized that THM's are only part of the chlorinated byproducts, many of those being identified being compounds known, under certain conditions, to be toxic.

Alternatives to chlorination most frequently considered are the use of ozone and chlorine dioxide. Ozone has been extensively employed in some countries, notably France, for almost eighty years. It is a more powerful oxidizing and disinfecting agent than chlorine but, unlike chlorine, has no residual disinfectant action in the distribution system. On-site generation equipment is required and the overall process is more expensive than chlorination. Ozonation reaction products are still relatively unknown; epoxy by-products have been postulated and extracts prepared from supplies treated with ozone have been shown mutagenic by some workers. Chlorine dioxide does not give rise to THM's but a major disadvantage is the production of chlorate and chlorite which may be of health significance when ingested regularly.

In modern treatment technology, a wide range of chemicals may be used including salts of iron and aluminum, flocculation adjuncts, activated silicates, alginates, synthetic polyelectrolytes, pH adjusting materials and disinfectants. Many of these, particularly the so-called "technical" grades, are potential sources of contamination.

The third category of contaminants referred to in Table 1 are those that originate in the materials used to construct treatment plants, storage facilities, distribution systems and plumbing fixtures, including point-of-use devices in the home.

Asbestos-cement piping may contribute to the asbestos content of drinking water, particularly where the water supply has aggressive qualities. In Winnipeg, for example (a city with aggressive water), some samples from the distribution system contained 6.5 x 10^6 fibres/litre compared to 0.3-0.4 x 10^6 fibres/litre at the water works. Although several epidemiologic studies have been reported, all but one were ecological in nature and insensitive because of a large number of confounding variables. In one case-control study conducted in the Seattle area, the authors noted various inconsistencies in their results but concluded that their study did not provide evidence of a cancer risk due to the ingestion of drinking water.

Uptake of metals from pipes, storage tanks and plumbing fittings is a universal occurrence. Concentrations of metals such as copper, cadmium, zinc or copper are usually low but can become elevated when water stands for a long time in the pipes, especially in new pipework lacking protective deposits. Soft, acidic waters distributed in older systems containing lead-lined storage tanks and lead pipes have resulted in concentrations of lead substantially greater than 100 ug/L in the United Kingdom and elevated levels of several metals have been found, after standing, in cottages drawing water from lakes affected by acid rain.

Plastic structures can also contribute to contamination of drinking water supplies through leaching. Examples include vinyl chloride from certain grades of PVC piping, although PVC piping that meets standards and specifications such as those of the National Sanitation Foundation should not give rise to this kind of problem.

There are, therefore, many ways in which chemical substances can contaminate supplies of drinking water. The question is: to what extent do these represent a hazard?

I would like now to consider the potential impact of chemicals in drinking water on human health. In this context, I must first discuss the significance of water as a vehicle whereby man is exposed to substances dissolved in it. Clearly, the hazard posed by any substance is dependent upon its toxicologic properties, especially its potency but the dose (the important pharmacologic parameter) is an integration of exposure by all conceivable routes. One cannot consider drinking water in isolation for many substances are introduced into the body through food, air and even by absorption through the skin resulting from occupational use. Table 2 shows the relative importance of drinking water as a vehicle for several contaminants that commonly occur.

Table 2

CONTRIBUTION OF DRINKING WATER TO

THE TOTAL DAILY INTAKE FOR CANADIANS OF TOXIC SUBSTANCES

TOXIC SUBSTANCE	CONCENTRATION IN CANADIAN DRINKING WATER (ug/L)	ESTIMATED CONTRIBUTION TO TOTAL DAILY INTAKE (%)
Trihalomethane (THM)	22.7	45
Mercury	0.2	3
Lead	≤1	1.2
Cadmium	≤0.02	0.06

Organic chemicals present in drinking water have assumed particular importance in the public mind, partly because of the discovery that THM's are formed in the chlorination process, partly because advances in analytic methodology during the past twenty years has provided the means to identify and measure minute quantities of organic chemicals that previously went unnoticed and partly because the application of these techniques to groundwater (previously regarded as pristine) has led to surprising results in some regions of the U.S.

Figure 2 is a schematic demonstration of the occurrence and distribution of chlorinated organic substances. It is of interest to note that total organic chlorine in drinking water is substantially higher than that in raw waters, that THM's account for about one-fifth of organochlorines in drinking water (compared to about one-thirtieth in raw water) and that 75-90% of the organochlorine fraction is non-

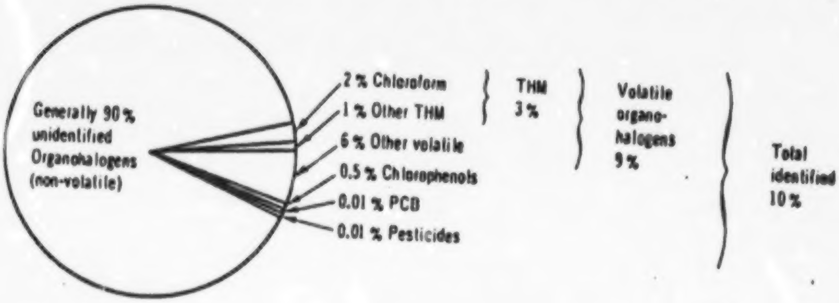
Figure 2

TYPICAL DISTRIBUTION OF ORGANOHALOGENS IN WATERS IN INDUSTRIALISED COUNTRIES

This figure illustrates a typical distribution of organohalogenated compounds that may be found in raw waters drawn from polluted rivers in industrialised countries and in treated waters (after chlorine treatment).

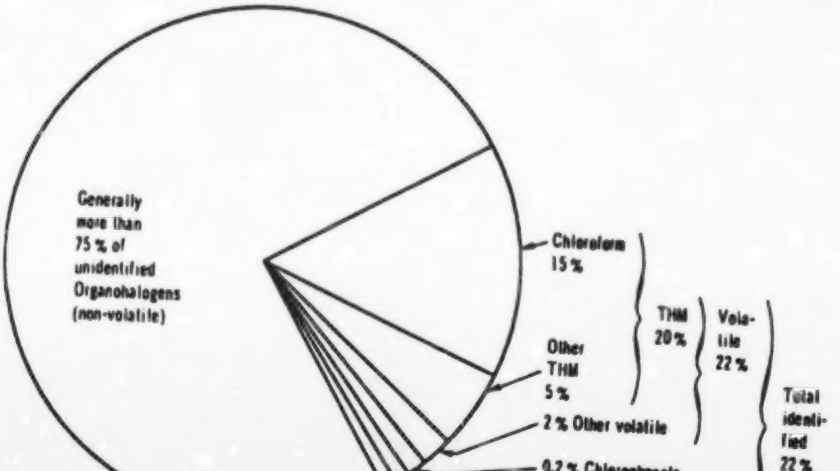
RAW WATERS :

RANGE TOCl = 10 to 100 μg/l
RANGE THM = 2 to 20 μg/l



DRINKING WATERS :
(after treatment)

RANGE TOCl = 50 to 500 μg/l
RANGE THM = 10 to 100 μg/l



Ref: OECD (1982). Control Policies for Specific Water Pollutants. Paris, p. 181.

volatile and remains still to be characterized. It is of interest to note that, in 1979, scientists from fourteen countries, under the auspices of the NATO/CCMS Drinking Water Pilot Study, pooled current knowledge which resulted in a list of 744 chemical compounds identified in drinking water. Kraybill has reported that 765 chemicals have been identified in drinking water, of which 20 are recognized carcinogens, 23 suspect carcinogens, 18 are carcinogenic promoters and 56 are mutagenic compounds. The majority of compounds identified to date are volatile, non-polar compounds; presently, attention is shifting towards the non-volatile which make up 80-90% of the DOC using techniques such as HPLC.

In conclusion, I would like to refer briefly to studies undertaken by the Department of National Health and Welfare to obtain insight into drinking water consumption patterns in Canada. The average consumption of tap water and tap-water based beverages is 1.34 litres daily, a figure that agrees well with figures from similar surveys in the Netherlands and the U.K. However, approximately 10% of the population consumes at least one litre more each day, and about 2% consume in excess of 4 litres daily. Relating these statistics to the potential intake of chemical substances, it is important to realize that the "dose" received by about one-half million Canadians (i.e., 2% of the population) corresponds to an intake of at least twice that allowed for in the development of the Guidelines for Drinking Water Quality where MAC's were derived on the basis of a 2 litre intake. At the same time, one may also note that less than half of the water consumed is taken as it comes from the tap. Especially in adults, more than half is consumed as coffee, tea or other beverages made with boiling water. This will, of course, significantly reduce the content of volatile organics. Finally, I should point out that the average tap water intake expressed in terms of millilitres per kilogram of body weight is highest in children, a fact that should not be overlooked since drinking water is a vehicle of some importance with respect to lead and nitrate, contaminants for which the "high risk" segment of the population is the young child.

DR. JOSEPH COTRUVO

DIRECTOR, CRITERIA AND STANDARDS DIVISION
OFFICE OF DRINKING WATER
U.S. EPA

CONTAMINANTS IN DRINKING WATER

Contaminants in Drinking Water

Dr. Joseph Cotruvo
Director, Criteria and Standards Division
Office of Drinking Water
USEPA

It is a pleasure for me to be here in Ottawa again and to be talking with you about drinking water quality issues. These issues that you are discussing here are very similar to the issues that we have gone through in the development of our safe drinking water program. They are very complicated of course, and it is very difficult to divorce the health concern from the fact, from the hypothesis, from the potential. But nevertheless, all of us feel that it is essential that there be very high quality drinking water available to the public, that there should not be any question in people's minds as to the quality of their drinking water, and that it is our collective responsibility, as water quality professionals, to assure that is the case. We provide the treatment and the controls over contamination at the source, and we are involved in establishing quality specifications. Together, we must assure that the public does not have any significant risk from exposure to drinking water contamination, and that the public should be confident that their drinking water is safe.

I would change my subject from the discussion of hazards in drinking water, to rather contamination in drinking water, or about adulteration of drinking water. There are a wide variety of substances in drinking water and in some cases, there are indeed clear imminent hazards; fortunately, those cases are relatively few. But there are also other cases where there is potential for concern or risk, and then there are others where this is relatively speculative. And so rather than lumping them all together as hazards, such that every single substance once found automatically is concluded to be a hazard - I think we must make some differentiation. We have to deal with risks that we understand in a particular context, and those that we do not know very much about in another context.

In general we have to conclude - both in the United States and in Canada from my understanding - that by all reasonable measures the drinking water is safe. Public water supplies are safe. Now, obviously, that does not mean that all of them are absolutely, and unequivocably free from every possible contaminant or every possible risk that could be there. We know that there are examples where there is very significant contamination, and we know that groundwater is a matter of increasing concern as more of these detections occur. That is real! We must deal with those. But that does not mean that people should approach their glasses of drinking water with fear and trepidation in the vast majority of cases. It also does not mean that we should not be concerned that drinking water potentially can become contaminated. I think that our main concern here and in the U.S. Government, is to be sure that we do not permit contamination to occur, that we prevent it, that we reduce it whenever we can; and we do that aggressively! But the proper perspective is also important.

Safety is not a precise term. We would have to say that our safety in this room right now is not precarious in the sense of an airplane crashing into it in the next hour. That is a very low probability event. None of us is concerned about that happening, but nevertheless, it is important that the airlines take special precautions to ensure that they fly safely. And that is what we are doing in drinking water: we are ensuring - as a goal - that drinking water is as good as it can be!

The other thing we should keep in mind is that except in relatively unusual cases, drinking water is not the principal or even a major source of exposure to most environmental contaminants either industrial or otherwise. Air happens to be a very significant source, both from occupational exposure and from indoor contamination. Food can be a significant source of natural and synthetic toxicants. Drinking water is uniquely the most significant source to those substances that are associated intimately with drinking water production, especially disinfection and other treatment processes. So, obviously that requires special attention because we have complete control over it. We do not have complete control over the other sources of contamination, and however, still, we have to be diligent.

The nervousness that develops in this area is that as analytical science keeps improving we keep detecting more and more things in drinking water as with everywhere else in the environment. The problem is that analytical chemistry is running about three or four or five orders of magnitude ahead of the ability of toxicologists and epidemiologists to determine the consequences of that exposure. So we have a lot more questions than we will ever be able to answer. I do not think, and I cannot even conceive under the most exceptional developments of science that one will ever be able to say with any degree of certainty what the consequences are of exposure to small amounts of various substances individually, let alone in combination. So we will never answer that question, ultimately, absolutely!

The traditional approach, as we are told from the water industry, has been to deal with problems in a sort of best practical/available technology process, is probably the best one to continue. In 1900 or near that time when chlorine was just beginning to be used in the disinfection of water, if the scientists had taken over and determined that before one could make that adjustment to treatment processes, we first had to identify each of the particular microorganisms that could possibly be in drinking water and then found its particular potency and frequency, and found its particular susceptibility to treatment and chlorination, we would probably still be wondering whether or not chlorine should be added to drinking water. So the point is someone made an excellent gut judgment in that time - and it saved millions of lives. There were lots of uncertainties. But it worked. It was cheap. It solved the problem conceptually as opposed to dealing with the problem in its minute sense. And, in a sense, we need to keep thinking along those lines. The engineers need to think along those lines as they are designing water treatment systems. It is not so important necessarily to deal with specific individual chemicals, it is better to deal with classes and groups of contaminants as they design their systems and to optimize them to produce high quality water.

Interim Drinking Water Regulations

In the rest of the presentation I will give you an idea of the activities going on in the United States in implementing the Safe Drinking Water Act: how we are evaluating our current regulatory activities; what we are going to be doing over the next couple of years; and our general perception of the significance of certain kinds of contaminants that are found in drinking water.

The existing interim regulation in the United States consist of approximately 40 substances. They are very comprehensive, although not totally encompassing, they do include the broad spectrum of contaminants that can be in drinking water. They are, in fact, very similar to the Canadian guidelines. They include the traditional biological contaminants, coliform and turbidity; a spectrum of inorganic contaminants that are still most frequently found in drinking water from various sources; six organic pesticides; radionuclides, and finally trihalomethanes. In addition to those primary standards, there is a series of secondary standards that are not dealt with as matters of public health concern but more as a matter of aesthetics.

Revised Regulations

Our management scheme for reviewing and revising all of the existing regulations is controlled by the fact that there is such a tremendous number of additional substances that must be considered in the revisions. The first time around the Congress told us to concentrate on those substances that were in the U.S. Public Health Service guidelines and we did that, and extended them somewhat to the trihalomethanes and radionuclides. But since that time, analytical chemistry has been so intensively applied in drinking water systems around the U.S. that we found more substances and, so, we have to consider them for regulation. The task was divided into four groups (Table I): the first is a volatile synthetic organic chemicals and these are chemicals like trichlorethylene and tetrachlorethylene which are most frequently found in groundwaters. The first data on those substances did not appear until 1978/79. And that was the initial shot and the list has been growing since then.

In the second phase, we will be dealing with the greatest number of substances and the greatest variety. The organics are primarily pesticides and other synthetic organic chemicals, often just discovered in the last years as potential contaminants in groundwater. We are examining all of the old inorganics and considering additional ones - and then taking a comprehensive new look at the microbial contaminants going far beyond just coliforms and turbidity.

Phase 3 is a new look at the radionuclides and that will occur beginning next year. Phase 4 is a comprehensive re-examination of disinfection byproducts starting with the THM's but, of course, going far beyond because a tremendous amount of new information has been developed since the 1979 THM interim regulation was issued.

Phase I Regulations

These 10 chemicals (Table 2), the volatile synthetic organics (VOCs), were selected as our evaluation group because of frequent detections in groundwaters. They are among the most common synthetic chemicals that are manufactured, many of them in millions of pounds per year quantities in the United States alone, relative inert substances, and fortunately, mostly relatively non-toxic except benzene for example. That is one of the reasons that they are so widely used because they do not have immediate toxicology associated with them in most cases, there are a few exceptions.

In order to improve our understanding of the true occurrence of those substances in drinking waters in the United States, particularly groundwaters, we completed a major national survey of 1000 groundwater supplies in two groups, and half of the group - approximately 500 was randomly selected (Table 3). On frequencies, as one would have expected, tetrachlorethylene, trichlorethylene, 1,1,1-trichlorethane and the dichlorethylenes were the most frequently found. Approximately 25 percent of the samples that were collected randomly were positive for one or more of these substance.

The detection limits were on the order of two tenths of a part per billion. Approximately 90 percent of those positives were very close to the detection limit, less than one part per billion. My suspicion is that many of those 90 percent that were close to detection limit were either the leading edge or the trailing edge of a plume of contamination, but more probably, the result of atmospheric fallout being brought down in rain and migrating into relatively shallow aquifers. The average levels were usually about one part per billion or less across the board. Only about one percent of the random group exceeded 5 parts per billion. Obviously, there are cases where one would find considerably higher concentrations, but in general at these levels exposures from sources other than drinking water are usually by far much more significant in terms of daily body burden. As an example: benzene, one of the major components of unleaded gasoline is certainly found in groundwaters as perhaps a tracer in cases of leaking underground storage tank occurrence. But still, except in very unusual cases, inhalation of air is going to give a much greater dose than the few micrograms that one might occasionally get in drinking water. We have to keep that perspective in mind-which however, does not say we are not concerned about drinking water.

Within the next few weeks, our first proposal of recommended maximum contaminant levels for nine of these substances is going to be published and that will trigger the major regulatory actions toward eventually arriving at specific maximum contaminant levels for these substances in drinking water.

Phase II Regulations

The second group of substances that is being examined for revised regulations consists of the synthetic organic pesticides, the broad spectrum of inorganic chemicals and the biological contaminants (Table 4). Among the inorganics (Table 5). This first group is the group that is already regulated in the National Interim Primary Regulations, and in many cases the numbers are going to change from what they originally were.

In addition to those, we are re-examining a much longer list of chemicals including such well-known substances as asbestos and sodium and others like copper that is a corrosion product in many distribution systems, and aluminum which is one of the major substances used in the treatment of drinking water. I think the most concern in this group of substances is those that are produced as a result of corrosion where water in contact with piping leaches out metals such as lead, copper, perhaps zinc and other substances that are present in distribution systems.

Among the synthetic organics that we are examining for possible regulation (Table 6) there are six that are already regulated in the interims - all pesticides. But in the second group that is being examined, about 75 percent of these are pesticides, and they include such items as ethylene dibromide, dibromochloropropane, aldicarb and many other pesticides which in recent times are being found in areas where they were applied for agricultural use. We will not necessarily regulate all of these substances. We are concerned about pesticides that are migrating to water supplies, and about pesticides that are used as part of the control of waterborne pests, either in water supplies themselves or in the watersheds.

Among the biological contaminants (Table 7) in addition to the original existing standards of coliform and turbidity which have served very well, we know a lot more about biological contamination of drinking water than was known in 1912 or so when the first standards were proposed. In the United States, in about the last ten years, there were at least 20,000 cases of waterborne giardiasis that have been identified. In 1980 alone, there were somewhere between 20,000 and 100,000 cases of waterborne diseases of various sorts. Most of them go unreported. So I do not think there should be any complacency about the fact that biological contamination in many places, because of inadequate treatment or inadequate source protection is still a very significant visible risk from drinking water consumption.

Viruses are the perennial concern and again, a matter of inadequate treatment or inadequate source control in some situations. From various monitoring that has been done, it appears that legionella are very common organisms inhabitating water distribution systems and home plumbing systems, which is not to say that ingestion of water-contagious legionella causes Legionnaire's Disease. But it does appear that the root of infection may be from inhalation of the organisms by susceptible individuals. Here is a case where we may be dealing in a hybrid where this may be a contaminant in drinking water but the transport of that from the water to the air and the inhalation may be the cause of a problem. The same thing may go for VOCs and may go for one of the next group, radon, which is a gaseous radionuclide found naturally in certain areas of the country. In addition to those radionuclides that have already been regulated, we are seriously looking at natural uranium and natural radon. (Table 8)

Phase 4 (Table 9) is a comprehensive re-examination of all disinfection-related products, starting with the trihalomethanes but going much beyond them. There is a much greater understanding now about the byproducts of disinfection, the organics, but also the disinfectants themselves like chlorine and chlorine dioxide that are used in some situations. These that are deliberately added to the water almost invariably are there in much greater quantities than any inadvertant contaminant that one would ever find in a drinking water supply; they not only the largest population exposed, but also likely the highest concentrations.

Compliance with Regulations

Table 10 provides an idea of some of the compliance results in the
United States since the implementation of the Safe Drinking Water Act interim regulations. There are about 59,000 public water systems in the United States and they serve somewhere between 180 and 200 million people, 3,000 of those exceed 10,000 persons in population; the other 56,000 are on the low end, they serve less than ten percent of the population.

About 50,000 of the 59,000 have not reported violations in a recent count. There are still about 1,000 persistent biological contaminant violations even when all it takes is chlorination to prevent it happening. This is a small coummunity system problem. There is still intermittent contamination occasionally reported and still turbidity problems in surface water supplies that are not filtering. There were about 500 violations of radionuclides standards-all natural radium. There were about 1,500 to 3,000 inorganic standards violations, half of these are fluoride, the others are odds and ends - a few arsenic, a few selenium and so forth.

The water quality situation is better now than it was ten years ago before there was a national regulation. However, there isn't any magic solution that occurs. There still can be non-compliance. The question is to continually move forward toward getting the maximum possible number of communities having the best quality water that they can reasonably have.

Conclusion

So in summary, what I would like to leave with you is that there are a number of potential contaminants in drinking water that are of concern. Contrary to what we believed on the passage of typhoid and cholera and other waterborne diseses in North America - biological problems still do exist. There is no reason for them to exist because we know how to deal with them. We know how to filter water and disinfect water. The problem is making it happen in those places where it does not happen, mostly the small communities. There is still particular concern with corrosion-related products and with disinfection byproducts - those are the substances where one has the largest population exposure potential and often highest concentrations. There is particular concern, especially recently, about groundwater contamination, especially pesticides and some of the synthetic organic chemicals that may be found. However, keep in mind, there are many other routes of exposure to most of those substances besides drinking water and it is important to control them too.

People that are in water industry should present themselves as people who are aggressively trying to stop these things from happening, aggressively trying to control contamination where it exists, prevent it from occurring, and treat it when it does occur.

We all agree that it is intrinsicly good to have clean drinking water. It is essential; it is a birthright maybe! I also do not believe that we need to justify providing clean safe drinking water on the premise that drinking water contamination is significantly related to cancer risks in the general population; it is extremely unlikely to be the case much as Bruce Ames has recently pointed out. But it is important that drinking water be clean and safe and that we as a society decide that we are going to make it as clean and safe as we can possibly make - because there is no need to tolerate less, and the cost is reasonable.

There are three areas that need to be emphasized: preventing contamination of drinking water sources; providing treatment when it is needed, that is tailored to the type of contamination; and of course, monitoring to ensure that we know what is in the water so that we can take appropriate action when it is found and needs to be dealt with.

TABLE 1

Regulatory Framework

Phase I	**VOCs**
Phase II	**Organics/Pesticides, Inorganics, Microbials**
Phase IIA	**Fluoride**
Phase III	**Radionuclides**
Phase IV	**Disinfection By-Products (e.g. THMs)**

TABLE 2

Phase I : VOCS

Trichloroethylene

Tetrachloroethylene

Carbon Tetrachloride

1, 1, 1- Trichloroethane

1, 2- Dichloroethane

Vinyl Chloride

Benzene

1, 1- Dichloroethylene

Dichloromethane

Chlorobenzenes

TABLE 3

Summary of GWSS Occurrence Data

RANDOM SAMPLE

n=466

Parameter	Frequency %	Maximum ug/L
TETRACHLOROETHYLENE	7.3	23
TRICHLOROETHYLENE	6.4	78
1,1,1–TRICHLOROETHANE	5.8	18
1,1–DICHLOROETHANE	3.9	3.2
1,2–DICHLOROETHYLENES (cis and/or trans)	3.4	2.0
CARBON TETRACHLORIDE	3.2	16
1,1–DICHLOROETHYLENE	1.9	6.3
m–XYLENE	1.7	1.5
o–+p–XYLENE	1.7	0.8
TOLUENE	1.3	2.8
1,2–DICHLOROPROPANE	1.3	21
p–DICHLOROBENZENE	1.1	1.3
BROMOBENZENE	0.9	5.8
ETHYLBENZENE	0.6	1.1
BENZENE	0.6	15
1,2–DICHLOROETHANE	0.6	1.0
VINYL CHLORIDE	0.2	1.1
DBCP	0.2	5.5

TABLE 4

PHASE II

- SYNTHETIC ORGANIC CHEMICALS/ PESTICIDES
- INORGANIC CHEMICALS
- MICROBIOLOGICAL CONTAMINANTS

TABLE 5

PHASE II : INORGANIC CHEMICALS

- **NIPDWR :**
  - Arsenic
  - Barium
  - Cadmium
  - Chromium
  - Lead
  - Mercury
  - Nitrate
  - Selenium
  - Silver
  - Fluoride
- **Other IOCs :**
  - Aluminum
  - Antimony
  - Molybdenum
  - Asbestos
  - Sulfate
  - Copper
  - Vanadium
  - Sodium
  - Nickel
  - Zinc
  - Corrosion
  - Beryllium
  - Thallium
  - Cyanide

TABLE 6

PHASE II : SYNTHETIC ORGANIC CHEMICALS (SOCs) / PESTICIDES

o NIPDWR

Endrin
Lindane
Methoxychlor
Toxaphene
2,4–D
2,4,5–TP (Silvex)

o OTHER SOCs

Chlordane
Pentachlorophenol
Atrazine
PAHs
Phthalates
Acrylamide
Butachlor
Dalapon
Picloram
1,2–Dichloropropane
2,3,7,8–TCDD (Dioxin)
Acrylonitrile
Hexachlorobenzene
Aldicarb
DBCP
Simazine
PCBs
Adipates
Dinoseb
Alachlor
Diquat
Endothall
Vydate
Toluene
Xylene
Styrene
Glyphosate
Carbofuran
Epichlorohydrin
Formaldehyde
Endothall
Heptachlor
Ethylbenzene
Freons
Trichlorobenzene
Ethylene Dibromide
1,1,2–TCE
1,1–Dichloroethane
Hexachlorocyclopentadine

TABLE 7

PHASE II: MICROBIALS

- NIPDWR
  - COLIFORMS
  - TURBIDITY
- OTHER MICROBIALS
  - GIARDIA LAMBLIA — TREATMENT REQUIREMENT
  - STANDARD PLATE COUNT
  - VIRUSES
  - LEGIONELLA

TABLE 8

PHASE III: RADIONUCLIDES

- NIPDWR
  - RADIUM 226 & 228
  - GROSS ALPHA
  - BETA PARTICLE/PHOTON RADIOACTIVITY
- OTHERS
  - URANIUM
  - RADON

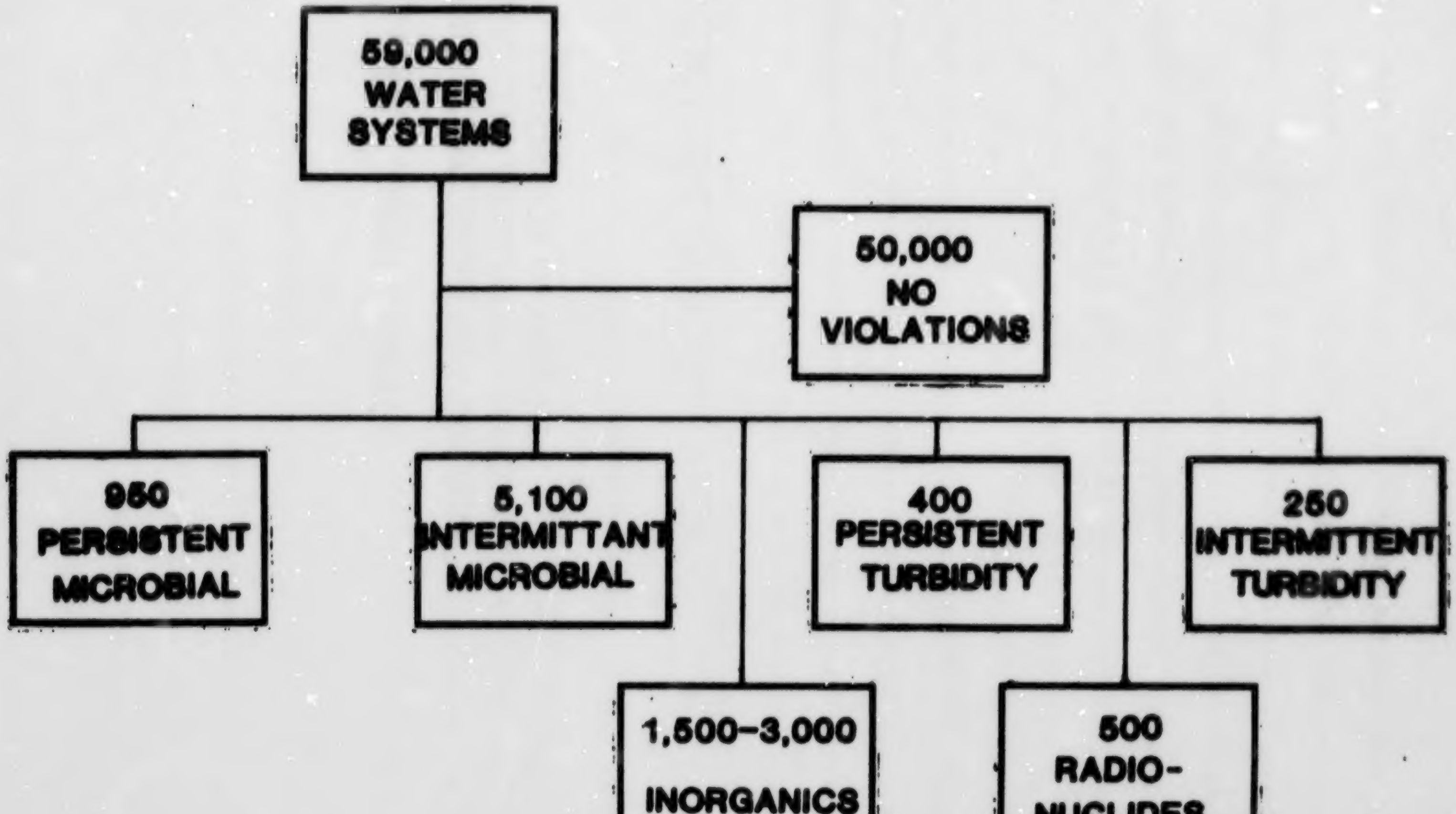
TABLE 9

PHASE IV: DISINFECTANT BY-PRODUCTS

- NIPDWR
  TRIHALOMETHANES (THMs)
- BY-PRODUCTS OF OTHER DISINFECTANTS
  CHLORAMINES
  CHLORINE DIOXIDE
  OZONE

TABLE 10

NIPDWR MCL COMPLIANCE


59,000
WATER
SYSTEMS
50,000
NO
VIOLATIONS
950
PERSISTENT
MICROBIAL
5,100
INTERMITTANT
MICROBIAL
400
PERSISTENT
TURBIDITY
250
INTERMITTENT
TURBIDITY
1,500–3,000
INORGANICS
500
RADIO-
NUCLIDES

DR. PIERRE PAYMENT

CENTRE DE RECHERCHE EN VIROLOGIE
INSTITUT ARMAND-FRAPPIER
UNIVERSITE DU QUEBEC

MICROORGANISMS AND DRINKING WATER

Microorganisms and drinking water

by

Pierre Payment,PhD
Centre de Recherche en virologie
Institut Armand-Frappier,Universite du Quebec
C.P. 100, Ville de Laval, QC, Canada H7N 4Z3

My talk will be centered on microorganisms only, leaving the topic of chemicals the other speakers. Even if drinking water poor quality is too often emphasized by wpaper headlines it is rare that microorganisms are involved. However most of us, ven the choice between a glass of water and a glass of milk, will choose the milk suming that it is relatively sterile. Strangely enough while the glass of water ntains a few hundred bacteria, the glass of milk may contain several million bacteria. both cases these bacteria are non-disease causing and even with the very high numbers milk both beverages are safe. This difference between pathogenic and non-pathogenic croorganisms is the most important factor in water treatments: the bacteria remaining ter treatment are non-pathogenic as the pathogenic strains have been eliminated by the sinfection processes. The same principle applies: water as milk should not contain thogenic microorganisms .

When asked if the water is safe to drink one must first evaluate its content. As have already implied, it contains very few microbial contaminants and while it is not erile it is usually very clean. The main reason for this clean water in most cities is e presence of efficient water treatment plants. Every day plants treat water ntaining several hundred thousands bacteria and deliver water almost free of croorganisms. The indicator bacteria used to measure the water treatment plant ficiency are indicators of that water quality: the water distributed is free of any of these indicators wether they are coliforms, streptococci or staphylocci. Pathogenic microorganisms are rarely searched for in drinking water because there presence would be a statistical oddity. For example viruses can be detected in drinking water and several laboratories have found them in waters bacteriologically safe. Their presence is not an indication of non-potable waters but in the amount found only a reflection of very sensitive techniques and higher pollution of the source water. A zero-pollution level is not attainable for viruses as well as it is not feasible to distribute distilled waer free of any contaminants to every home. To sample 1000 to 10 000 liters of water in a search for viruses as we can now do it in my laboratories is not very meaningful: to infect man the number of viruses to be ingested at the same time is more than 10 infectious viruses. If there is one virus per 100 liters one would have to drink over 1000 liters in one day to get infected.

The other question that must be answered is: why are so many people sick because of their drinking water?. The fact that it is their drinking water is not demonstrated and several other sources of contamination must be taken into account. The main complain about water is that it causes gastrointestinal symptoms. It is very clear that most of these symptoms can be attributed to contamination by other sources: food and in particular seafood very often contain toxins or bacteria producing gastrointestinal symptoms. Raw oyters can contain large amounts of viruses and chicken is easily contaminated by salmonellas. Contact is also a very common mode of infection: children with gastroenteritis easily contaminate the whole family by contact. Stress and alcohol can also provoque gastrointestinal symptoms as well as too much sun or spicy foods.

Recreational waters are also a source of contamination leading to gastrointestinal symptoms. Private swimming pools are the source of several epidemics of gastrointestinal diseases when they are not properly disinfected. While the result is an epidemic which is blamed on drinking water the case is quite different. Beaches like the ones we have in Quebec are a major source of gastrointestinal diseases: untreated sewage is discharged in our surface waters and constitute a very high risk of contamination.

It is also clear that there is a seasonnal pattern to gastrointestinal symptoms nd that this pattern is not related to the water quality but to the normal pattern of ransmission of enteric microorganisms in the population. A similar pattern is bservable with respiratory diseases which have nothing to do with drinking water. It is nown that at the end of summer there is an increase in the number of cases of astrointestinal disease and that a similar increase is observed in January.

Drinking water can also be at fault when the water treatment plant is not roperly operated or when normally non-pathogenic bacteria are too numerous in the istribution system :a few individuals can develop minor gastrointestinal symptoms. Most f the time when an outbreak is related to drinking water there are two possible easons: water which was normally safe to drink without treatment has become ontaminated (e.g. pure source water contaminated by animal or human excrements or well ater contaminated by nearby cesspools) or a failure in the water treatment that is sed to disinfect contaminated water. Whatever the reason the organisms responsible for he outbreaks are the one that have been described by the previous speaker. Hepatitis A irus, rotaviruses, Norwalk virus, Giardia, Salmonella and Shigella are the most requent etiological agents involved.

The failure of a treatment plant can occur at any step of the treatment and the ore contaminated the raw water used the greater the risk of a breakthrough of icroorganisms if the system is not well maintained. These problems are not acteriological problems but engineering problems which have to be dealt with by echanical means. The bacteriological analysis is only and indication that a mechanical ystem has failed and the answer is obtainable only after 48 hours or more while the onitoring of the mechanical process can result in instantaneous answers.

The water treatment plants act only as a filter between the pollution we have reated in our surface or ground waters and ourselves. The overload of our water iltration plants by increasing the discharge of untreated sewage in these water can nly increase the risk of passage of microorganisms up to our taps. This filter cannot be rendered more efficient except by means which are too costly and do not make common sense. It is evident that, as it is not an absolute filter, some microorganisms will go through: if only one in a million can pass the filter the risk is negligible especially if the raw water contains only a few hundred. On the contrary if the raw water contains several million microrganisms the risk will be increased.

The best answer to better quality drinking water is a better quality of raw water. The increase in the number of treatments or the addition of more sophisticated treatments is not the answer. All the standards that have been implemented relate to the finished product and in order to meet them we are increasing treatments steps without asking ourselves if we are working on the right end of the problem. The problem is what is coming in the plant, why it is getting there and whose responsability it is. The treatment of wastes before discharge in the water is a necessity if we want our drinking water to remain safe to drink.

As I said earlier, water that has been treated is usually microbiologically safe to drink. The quality of the drinking water relates to the quality of the raw water used and to the quality of the material and personnel used to treat it. The regrowth of non pathogenic bacteria or the presence of viruses in very low numbers do not represent problems because of their low numbers. They must however be assessed on a regular basis to insure that they do not exceed values that can be considered as unsafe for drinking. It is however my opinion that most drinking water in this country are safe to drink from the microbiological point of view.

UNEDITED TRANSCRIPTION

Question and Answer Period

Rip Rice

I am a consultant in what I choose to call "advanced drinking water technologies" and I will be talking to you on ozone in the morning. This afternoon, I have a question on some other part for my dear friend, the second speaker from the U.S. E.P.A., Joe.

In the second-to-last slide in which you break down what you are going to be doing in the oxidation products, disinfectants, you list ______, chlorine dioxide and ozone. But you do not list chlorine. And I think that is a bit of an oversight because chlorine, of course, is a chlorinating agent and that's what gives us the TH terms, chlorinated compounds and so forth. But it is also an oxidizing agent and in many cases it gives not only similar but the same oxidation products as pure CoO2 as ozone, as KmO4 and so forth.

Secondly, you should certainly have it in there because when you are making CoO2 by the "normal technique," you have excess Co2 in with the CoO2. And if we ignore the oxidation products of chlorine, we are just overlooking a problem which is going to come down the road later on. And in that context, somebody form Dow Chemical that works on bromine, bromine chloride had pointed out a few years ago some data which said that if you look at the mix of the oxidation products of chlorine versus chlorinated products, 90 percent of the chlorine is used in making non-chlorinated oxidation products and only 10 percent for the chlorinated products. I hope you take that into consideration.

Dr. Joe Cotruvo

Yes, thank you, Rip! You are correct! Of course I didn't list chlorine because I was lumping it in with the THM's and the other byproducts and perhaps that was an oversight. I think we know a lot about other chlorinated byproducts besides THM's. It turns out that a large percentage of them seem to be chlorinated acids like trichlorocidic acid, dichlorocidid acid and, also, I would speculate to say that the oxidation products that you are talking about, chlorine, ae probably very similar to the oxidation products that come from ozone too.

Rip Rice

Yes. There was some work done by Carlson and Cable about six years ago in which they took aqueous solutions of compounds like ____ acid, treated them with pure chlorine and with pure ozone. They isolated many oxidation products one of which was the first apoxide that you can form of that double bond. So you can get the same toxic compounds if you will in many cases from almost any of the oxidents.

Daniel Green

I guess it's understandable that the two government representatives presented the data on a very statistical point of view. As an environmentalist, I usually get work on the worst scenario situations where you have a population being exposed to very high concentrations of either bacteria or chemicals. Very often, public servants forget about the exceptions and as far as the managerial approach which you sometimes have to take because of your grave responsibility, you tend to put in the back of your minds the situations we lived for instance in Quebec in Ville Mercier. Situations that regularly people living in the ________ Basin have to live through. Relationships between water quality and leukemia... These, of course, you can consider as worst scenarios but should not forget them in your responsibilities.

Another thing that I would like to say is that - and I think that Dr. Payment mentioned it - is the fact that we want to have a definition of what clean water is, as far as Canadian citizens, the impact of this demand, a public demand, did not really come out from the disorganized public. I have a perception, maybe I am wrong, that the push for water standards is also an effort done by the waste waterworks lobby that have a lot to gain with either treatment facilities - and we see this in Quebec, La Cote is extremely present. They are doing, of course, a good job but I sometimes wonder if they are acting completely on behalf of the public interest and not sometimes on part of the private interest. I think it muddles the water a bit when you see that kind of pushing.

I think Dr. Payment said that what is the most important thing to do, I think, is to stop putting these microroganisms or giving the water medium a milieu for them to grow in such concentrations, when you think of the raw sewage being pumped into the St. Lawrence River by Montreal, for instance. And also stop the companies from making the public, the municipalities and the governments have to pay to give the public clean water when its private interests that are contaminating it. Make it easier for the waste, for the waterworks lobby to present to the governments, force the governments to spend billions of dollars for treatment of water, then to approach the industries that are contaminating the waters in the first place so they will install at-source treatment facilities. So I think that it's... we must not always say, Toronto, Montreal, Quebec City, Trois-Rivières have to give us clean water. We must also say that the industries must not contaminate the water forcing us to pay billions to guarantee the right to clean water. Thank you!

Dr. Payment

It serves the fact that we really have to separate what is industrial pollution and municipal pollution which is normal fecal - in terms of microroganisms, it's ourselves who are contaminating our water. So we must not put the emphasis on the industries for that pollution. We are polluting our river and then the part from the industries, it's quite a part, and it's easily taken care of, I think, much more than the municipal which is so huge in Quebec now. It takes very large amounts of money to take care of it.

Daniel Green

In Quebec, as far as the river system goes, take the ________ River, the problem is municipal and also waste coming from the pig industry which has over - the Quebec's water and the Quebec land cannot just accept that that amount of raw pig sewage in the river and, so, that is not municipal. That is a government decision, deciding that Quebec, back in the '70s, a pig importer will become a pig exporter. We have more pigs per capita than I think anywhere in the world. I think it is industrial strategies that should also be addressed as far as guaranteeing the right to clean water is concerned. It's not only a public municipal problem but the industry should have to address it also.

Roy Hickman

Well, I have a great deal of sympathy for what I think is an important point which Mr. Green made, and that is that really what we should be striving to do is to clean up our service in groundwaters to protect them to the point where, in fact, we need a minimal of treatment. I am very sympathetic to that point of view. And certainly I believe that the policy of the federal Government would support that principle. But I think we also have to recognize that many of our service waters are already, unfortunately, contaminated from practices of the past and perhaps continuing practices. And that therefore, and it is unfortunately we will have a legacy from that for many years to come. And we talked in some length about the situation in Lake Ontario, and certainly the problems which are posed by leaching from the toxic waste sites around the Lake Ontario, they are going to be with us for a very long time to come. Therefore, we do need to invest in treatment technology I think, simply because to rely on just cleaning up the water is not going to do anything. Jack Valentine, a scientist with Environment Canada, I think put it rather graphically when he was addressing some school children recently where he said, if a man headed out to Lake Ontario on a hot summer day and he perspired into the Lake, it would take 500 years before the sodium chloride that you perspired would be finally removed from the Lake. I think that was, if one divides the figures, there is a point made in that, where we have these situations, particularly in surface waters - that's going to be a very long time.

Also, I thank Mr. Green for reminding us about the what he called the "worst-case situation," which I prefer to call the "high-risk populations." And certainly we try to be mindful of these but there is sometimes a difficulty in detecting who these high-risk populations might be. And we have to rely very much on information from the local level. As a federal Government, we certainly need to be aware of those because I think it's important to know those when we are developing, for example, the guidelines. That's why we are particularly interested in finding out in terms of drinking water consumption, not what the mean figure is - I think we weren't very surprises of that - I think it is rather significant to find that approximately 2 in every 100 of us drink more than twice the mean figure, and yet we are basing our toxicology on an intake of 2 litres when in this room there are probably 4 people who drink at least double that amount and therefore presumably take twice as much of any toxic material that might be in the water into their system every day.

Steve Bonk,
Region of Ottawa-Carleton

Mr. Chairman, may I be permitted to comment on the first two addresses of the afternoon, we did have to addresses. I will keep them very, very short. Firstly, my name is Steve Bonk and I am with the Region of Ottawa-Carleton, and I am I guess very involved in getting you this low THM water that you are appreciating in the course of this two-day conference.

I have two hats, though. This afternoon, I'd like to comment on behalf of my capacity with the American Waterworks Association and namely a director of that association, a member of the executive board. And I would like to comment on Dr. Harris's statement that the waterworks community was totally opposed to the Safe Drinking Water Act. And also that they specifically opposed the THM, MCL of a 100 parts per billion and the provision requiring that the application of a specific treatment technique where a water source **may be** subject to organic contaminants. In fact, and I would like to state this quite categorically, that the waterworks community and AWWA have never been opposed to the Safe Drinking Water Act, but rather have been justifiably opposed to many of the terms of the Act, and specifically, the AWWA challenged the 100 part per billion THM MCL in the absence of sufficient data to justify such an MCL. And then with regard to the specified treatment technique, AWWA has challenged the term "may." And I say "may" in requiring a specified treatment where a water source **may be** subject to organic contaminants.

And I would like to further address Mr. Kline who made some remarks after that talk. And I would take strong exception to Mr. Kline's comments about the fact that our water systems are out of date and out of slate. As a representative of the water utility industry, I can assure this assembly that our industry has always been, is and will continue to be totally committed to the application of the best and most economical treatment technology in the production of a drinking water, meeting current standards. Thank you, Mr. Chairman!

Trevor Hancock,
CIAG and City of Toronto

I wanted to pick up on a point made from this morning and carry it over, and particularly ask Dr. Cotruvo and Mr. Hickman to comment on it. It has to do again with the issue of safety and we heard a definition of safe this morning as being state-of-the-art safe. The assumption, I assume, or the implication being that it meets current guidelines. Now we also heard that the current guidelines are presently being revised, the maximum acceptable concentrations and so on. And I wonder if the two of you would like to comment on the process, what is going on in that revision, in particular with reference to some quite startling differences that are present between some of the MAC's for some of the organic contaminants and the estimated 1 in 100,000 lifetime cancer risk figures. I mean differences in those of the order of 1 to 3,000 fold differences sometimes. And that's only for 1 in 100,000 lifetime cancer risk. The National Research Council describes the virtually safe dose as 1 in a million which is a ten-fold difference yet again, and in particular whether you like to comment on that in reference to those high-risk populations. Are we talking about toxicity to healthy adults, or are we talking about potential toxicity to infants, to the fetus, to elderly people and chronic illnesses and so on. Could you perhaps comment on those?

Dr. Cotruvo

I am not sure exactly what your question is. But I comment anyway. First of all, the fact that there are differences of MAC's or MCL's whichever the different countries use is not necessarily significant at all because, first of all, one is dealing in a continuum and as time changes, as new information is presented, things are always revised.

Secondly, I don't believe there are any really significant differences between them since, keep in mind, the objective in writing any standard is to provide a margin of safety to deal with the uncertainties. And, as you heard this morning, toxicology is not all that precise of a science and it always turns out that the biggest contributor to the final number is the uncertainty factor. And so one always tries to err on the side of safety and one can always debate whether the uncertainty factor should be times 50 or times 100 or 73 or whatever it may be in a given case. So there are bound to be differences because of time, new data, different judgments and each judgment must be made in a specific context. Ours was made in the context of our rules as stated in the Safe Drinking Water Act. There may be other rules. The European standards will be different. The WHO guidelines will be different. This is normal. I wasn't sure what you were getting at in the matter of the 1 in 100,000 risk situation. Were you saying that there are communities that have water that has concentrations of substances that are thousand times above the equivalent risk?

Trevor Hancock

My point was that the maximum acceptable concentration set for some chemicals, as best as I can understand it, are sometimes of the order f a thousand-fold greater than has been estimated in fact...

Dr. Cotruvo

Could you give me an example?

Trevor Hancock

To give you one example, the estimated exposure for dyeltrene, .71 parts per trillion, estimated to result in a lifetime cancer incidence of 1 in 100,000. The maximum triple concentration for dyeltrene presently in Canada is 700 parts per trillion which is a thousand-fold difference. So these are orders of magnitude of difference and that is that what I am trying to get at, and in particular is that being considered then in connection with the problem of particularly frail and sensitive populations.

Roy Hickman

Perhaps I can attempt to answer that for you because the figure that you quoted is I believe from the 1978 Guidelines for Canadian Drinking Water Quality. Is that correct? And at that time, this was before we accepted this philosophy of extrapolation of very low doses to estimate cancer risks as a regulatory tool.

Since that time, both Joe and I have been associated with activities of the World Health Organization which in fact have been developing WHO guidelines which in fact are based upon the linear extrapolation technique for carcinogens. We in Canada are currently, as I think was mentioned this morning, in the process of revising the 1978 Guidelines and I think what you will see in that - although it is too early for me to say definitively because the decisions are taken by a committee which have not yet taken the final decision on this - but I would not be at all surprised to see those brought into line with WHO recommended standards which are based on the linear extrapolation model.

Perhaps I could, while I have the floor, because I think it will answer some of the other aspects of what you are asking, give some indication and perhaps the the easiest way is just to read to you what those WHO guidelines are because it answers the questions that you are asking. It says: "A guideline value represents a concentration or a number which ensures an aesthetically pleasing water and does not result in any significant risk to the health of the consumer." It doesn't say it's safe. "The quality of water defined by the guidelines is such that it is suitable for human consumption and for all usual domestic purposes including personal hygiene. But water of a higher quality may be required for some special purposes such as renal dialysis. The guideline value is to be used as a signal, one to investigate the cause when values are exceeded with a view to take remedial action and, two, to indicate the need for responsible authorities to undertake investigations. The guideline value describes a quality of water acceptable for lifelong consumption and the establishment of these should not be regarded as implying that the quality of drinking water may be degraded to the recommended level. Indeed, a continuous effort should be made to maintain drinking water quality at the highest level of purity." And I think that comes back perhaps to Mr. Green's question. The danger, of course, by having levels is that it becomes almost a licence to pollute and certainly we don't want that to happen.

"The guideline values have been derived to safeguard health on the basis of lifelong consumption. Short-term exposures to higher levels of chemical constituents such as __________ and accidental spill may be tolerated but need to be assessed on a case-by-case basis, taking into account, for example, the acute toxicity of the substance involved." And that's because there is often no good correlation between the levels which produce chronic toxicity and acute toxicity and the guidelines are based on the acute figure. "The figures are intended to apply to all of the population including the elderly and the young children, where we know in the case, for example, of lead or nitrate there is a particular susceptibility for the infact. That was taken into account in arriving at the recommended number."

Dr. Joe Cotruvo

I would like to make a comment on risk calculations. First of all, I hope no one believes them. They are purely hypothetical, mathematical constructs. There are many different kinds of calculations, many different models that are used. Each of them gives a different result. The same models with modifications as is common in the hands of individual bio-statisticians also provides different results. It's unfortunate that... they do have use. They are not useful in predicting numbers of cases of cancer. I think they are useful in ranking substances on the basis of relative potency. They are useful in giving an indication that substance A, one microgrom of substance A, is probably more potent than one microgram of substance B; not useful in saying that therefore these many cases of cancer are going to occur. Even in that WHO report, the group was careful to say that at best these numbers should be taken with a broadness, a breadth of a couple of orders of magnitude at best. And, so, I'd say they are useful tools for priorization and for ranking. They certainly do not predict the numbers of cancers that are going to occur. So it's just unfortunate that they are always presented, the result is always presented at risk of 1 in 1 million, 1 cancer case in 100,000 - they don't do that. And of course we will never know what the actual risk is down on that low level of exposure. It cannot be experimentally determined.

John Howie,
Departement Sante Communautaire,
Montreal General Hospital

Two very brief questions, I will be very brief. One is, what proportion of the municipalities in Canada, and perhaps a question for Mr. Audet, whether Montreal regularly analyzes the chemical content of its water. And a brief question for Dr. Cotruvo. The slide which showed the random sample of the groundwater supplies in the U.S. was somewhat reassuring. But I wonder whether a random sample was the best way to get at that problem and whether sampling related to population density might be more appropriate. I can't imagine how one does a random sample of groundwater supplies. I wondered if it wouldn't be more useful to know whether the groundwater near the areas of heavy population density... that's really what we are after.

Roy Hickman

I can try and answer the first part of your question. The 1978 Guidelines on Drinking Water Quality had specifications relating to monitoring. It specified the frequency of monitoring, the number of samples to be taken and so on. We undertook a survey in late 1982 and found that in no province in Canada were these recommendations being totally observed, that the monitoring for toxic substances in general tended to be - the situation where a new source would be monitored rather intensively, but after that there would only be sporadic or no monitoring of many of the toxics involved. The routine monitoring which takes place tends to be for microbiological parameters, and for those which lead to complaints from the consumer. So there is rather good monitoring across the country for substances such as iron or turbidity because if those are not properly controlled, the waterworks operation very quickly gets many complaints. Unfortunately, monitoring for toxics appears to be not nearly so well undertaken at the present time.

Dr. Joe Cotruvo

On the second part of the question, the utility of random samples, you are actually right! There are weaknesses in doing random samples and in fact what I told you about was half of the study. The other half of the study, the other 500 samples were directed to areas of high risk or high probability of contamination based upon surface characteristics. In the case of the random samples as well as in the case of the non-random samples, the only real correlation which we found was with population. As we rated the data relative to the size of public water systems, we did find in fact that in those communities where the population exceeded 10,000, the probability of finding at least a trace of one of those substances was in the order of approximately twice as great as in the smaller communities. And in the matter of the directed sample, where we asked our states to pick sites which they thought had high potential because of a proximity to waste disposal sites or shallow groundwater or industrial activity or something like that, there was only a slightly higher frequency of detection of positives than in the random, which leads one to conclude that it's hard to predict where contamination will be based on surface characteristics. And again, however in that case where we found contamination in the non-randoms, the likelihood was that the concentration was higher than in the randoms. So if I have probably confused the situation, I am sorry.

The correlations were direct with size. The larger the size of the community the greater the probability of finding some contamination in the groundwater in the vicinity which is reaonable in retrospect when you go through it.

Secondly, when we looked at wells where there appeared to be a high probability of contamination, we found a slightly higher incidence of detection over the randoms, but not much, but when we found contamination the probabilities, the concentration was higher than in the randoms.

MR. BOB GOODINGS

VICE PRESIDENT
GORE AND STORRIE LTD.

HISTORICAL DEVELOPMENT OF WATER TREATMENT IN CANADA

The technology of water treatment in Canada is not very old when you examine the historical literature. Many of our grandparents, perhaps even our parents, were born into a world when modern water purification technology was in its infancy.

A complete history of water purification has been recorded in two volumes produced by the A.W.W.A. entitled: "The Quest for Pure Water - The History of Water Purification from the Earliest Records to the Twentieth Century". The books were printed to commemorate the first one hundred years of the A.W.W.A. Developments in Canada and the record of Canadian engineers and scientists are presented along with other giants in the industry. In Canada, the development of treatment process water really began less than a century ago. To supplement the A.W.W.A. data, I have delved into the files of the founders of our company, Mr. Gore, Dr. Nasmith and Mr. Storrie, and that of Region of Ottawa-Carleton, Metro-Toronto and the City of Edmonton. These files have provided a human dimension that brings history into focus about the past public attitudes and apathy. Today's difficulties have a familiar ring when we read of the problems and public pressures of yesteryear.

Progress in treatment or "water conditioning" over the years has always followed the parade of public concerns. The pace of progress varied from fast to slow, beginning with micro organisms and carrying on with the removal of turbidity, colour, dissolved minerals, heavy metals, radionuclides and exotic particles such as asbestos. Today's concerns are focussed on the removal of synthetic organics. Concern over water quality for human consumption led us through a series of changes in processes, the most important single step being disinfection by chlorination. The next step will be the investigations for the treatment of trace concentrations of synthetic organics. This next and important step requires our engineers and scientists and public health specialists to review all present water treatment processes. In reviewing the changes over the years, Dr. Abel Wolman of John Hopkins University Baltimore commented, when he reviewed Volume I of Quest printed in 1948 the "conclusion which may be drawn ... is that the history of 'conditioning or treatment' of water is largely a history of empiricism, a history of an art and not of a science." This has changed in the last ten years and water treatment is now a science with major involvement by many disciplines.

Disinfection of public water supply in Toronto began in 1910. The City of Edmonton records the change in disinfection methods from chloride of lime to chlorine gas in 1917. In the records, we found a display at the 1914 Toronto National Exhibition that indicated that some public education was needed to assure the citizens of the day that a little chlorine does a lot. Wallace and Tiernan became the major and almost exclusive manufacturer of gas chlorination equipment, a position they held in the market for forty years or more. Their glass jar vacuum feed machines were in every major and most small, water systems in Canada where chlorine was used.

The deaths in 1910 from typhoid and the level of infant deaths at the same time were astronomical. Dr. A.B. Moffat of the Department of Health of the City of Toronto, reported a drop in typhoid fever deaths per 100,000 population from 44.2 to 0.9 from 1910 to 1928. In the same years, the infant mortality rate per 1000 live births dropped from 139.2 to 60.3. This, he attributed in part to chlorination beginning in 1910 and complete pasteurization of milk in 1914. He says, "the Toronto citizen now accepts his safe water, milk and food supply without much thought as to how it came to be safe or what efforts are required to keep it so".

In a communication from the Canadian Tuberculosis Association to Dr. G.G. Nasmith in 1925, Dr. Robert E. Wodehouse was lamenting the apathy of the medical people and of the governing bodies of a Maritimes community, which had rescinded the general pasteurization order and allowed the continuation of a makeshift chlorination plant for the water supply. He had hoped that Dr. Nasmith would do a study on their water supply and "publish the findings over the engineer's signature". In 1925, the infant mortality rate for infants under one year in that Maritimes community was said to be 97.4 per 1,000 births. Dr. Wodehouse wrote also on the introduction of the disinfection of water reportedly introduced in Toronto, Winnipeg and Edmonton, some ten to fifteen years earlier, commenting on the fact that their death rates due to typhoid were lower.

Today, disinfection of water supplies in Canada is almost exclusively by the use of chlorine. The use of ozone in Canada as the alternative system was reported to be in some twenty-three locations in 1978, most of which were in Quebec. Today, most of our scientists do not suggest the elimination of the use of chlorine in protecting the water supply, but are focussing on other measures at the pre-treatment phases.

In the last two decades of the 19th century and the first two of this century, inventors paraded an amazing number of filters - slow, pressure, drifting, upward, rapid, Warren, National, Roberts, American, Blessing and so on. Our City fathers could not have been anything but impressed and bewildered by their claims and advantages. Our own Mr. Gore was the inventor of the Gore-Ransome Drifting Sand Filter. A 60 mgd plant of his design was constructed on Toronto Island and put into service in 1918.

In the 1930's a major effort of engineers and inventors was to find ways of improving filter operation by pretreatment prior to filtering with the use of alum. The City of Ottawa, with Mr. Gore, conducted elaborate large scale pilot plant studies at the Lemieux Island plant to use alum to reduce the high colour levels in the water from the Ottawa River. The hydraulic spiral flow mixing tanks were perfected here and have been quite successful in many major plants in Canada. Other pretreatment processes using upflow clarifiers, circular clarifiers and similar units become available to the consultant and the municipalities. Basically today's plants are not much different except for higher settling tank overflow rates, mechanical flash mixers, the use of poly electrolytes, direct filtration and higher filter rates. Mechanical controls have given way to sophisticated, computerized systems which require fewer operators.

Water quality control and testing has advanced from simple tests, in the early 1900's, of chlorine residual, turbidity and colour. But even these tests were usually carried out only at major sized plants. I would venture to say that even today, some water plants in Canada still do not perform all of these basic tests even though low cost, easy to use equipment is available. On the positive side we find that many of the modern plants today possess modern laboratories with skilled staff. The City of Calgary has recently purchased a Gas Chromatograph/Mass Spectrometer (GC/MS) to search for trace organics, mainly pesticides. The costs to own and operate this unit are quite high when we consider other test procedures in most plants and this forward looking move is an indication of things to come.

The number of standards for water supply has changed from a single contaminant listed in the U.S. Drinking Water Standards (bacteria), to thirty-nine in the 1975-79 listing. Similar changes have taken place in the objectives listed by many of the Canadian provinces. The present number listed in the Canadian

Drinking Water Guidelines is 48. In the early years, up to 1962, the major criteria involved metals and esthetic concerns. The last years have seen the arrival of synthetic organics and radionuclides. In this next decade, I expect that the number of listed contaminants will increase by three to five times the present listings.

In 1984, we can look back and see that there has been a pattern and a systematic approach to solving problems in the water treatment processes. The steps can be considered to be in four phases:

- Problem first perceived
- Validation of problem
- Quantification
- Testing, experimentation and engineering assessment
- Assessment of health risk
- Technical and optimization of process.

If we reflect on the microorganism phase we can see from the historical data that these four steps did indeed take place. The microscope was a major tool in starting the industry off in the disinfection as a water treatment process. If we project this experience into today's world we can say that instruments such as the GC/MS, which measures minute quantities, will help engineers, scientists and public health specialists in dealing with society's modern problems in water treatment. The four elements needed for a public project to proceed to successful conclusion are: definition of the problem, technical answer, perceived need by community and available public money.

A major cost element in the production and distribution of water is the cost of manning the system on a 24-hour basis. The 50 mgd Lorne Park plant in Mississauga, Ontario, is an example of a plant in Canada operated remotely from another major installation 8 km away. The use of modern technology such as better measuring devices and computer based controls make this possible. Today, an ever increasing number of plants are operated on a day-shift-only bases with automatic operation for the other shifts. Some Canadian municipalities drawing water from rivers with wide fluctuations in raw water quality may have to wait a few years to reach this state, if in fact they ever do. Municipalities drawing water from lakes, or ground sources, with consistently good raw water quality, seem to be more able to operate on this basis.

Some members of the public say they want lower cost water; but an ever increasing number want "safe" water at a greater cost if necessary. "Trace Organics in Drinking Water" and "Risk Assessment for Drinking Water" were two booklets produced by our staff to help us and our friends in the industry develop a perspective on this complicated issue. Risk assessment which can be defined as "an estimation of the probability that exposure to a chemical at a particular level will cause an adverse effect in humans or other organisms" has been left to our Provincial and Federal Governments. It is not clear that the public will wait.

The past, present and prospects for the future of water treatment is summarized by the writings of a senior statesman and scientist with over sixty years of meritorious service to the water works industry of North America. In his prologue to the last volume of the "Quest for Pure Water", Dr. Abel Wolman, Professor Emeritus, John Hopkins University, Baltimore, Maryland writes:

> "Water, as a strong determinant of the health of its users, will be subjected to increasing scrutiny, simply because it is a universal ingredient in man's metabolism. The future will focus inevitably, upon the infinitesimal concentrations of organic and inorganic materials, if for no other reason than that we can now detect them. In the past, our tools of detection were gross. Now the time frame for possible effects is considered to be decades rather than days, insofar as carcinogenic, mutagenic and genetic potentials are concerned. The economic implications are many. Common sense, supported by epidemiologic, rigid scrutiny will ultimately prevail, if we can remain patient."

While it is difficult to make predictions with certainty, one trend is clearly emerging. More than ever before, the general public is developing deep interest in the reliability and effectiveness of treatment processes as well as the quality of the potable water it consumes.

UNEDITED TRANSCRIPTION

Question and Answer Period

Rip Rice,
Consultant

Bob, you had a slide up there that showed two 12-gallon bottles of water back in 19... humdihum - 1914. And it was a very small calcium hypochlorite volume there. Do you have any idea how that volume of calcium hypochlorite has changed over the years?

Robert Goodings

I'm sorry, I can't answer the question. And I have an idea it is a loaded question that you can probably answer yourself.

Rip Rice

I was just trying to save a little time.

Jack DeMarco,
Cincinnati, Ohio

Bob, I was wondering if in showing you typhoid death rate statistic, wheter you had any breakdown of prior to, say, sand filtration and after sand filtration. And then, correlatively, after the initiation of disinfection. Your numbers were rather similar to ours when we first put our treatment plant in in 1907. First it was sand filtration before chlorination. And we saw the death rate, our typhoid death rate, went from about 59 per 100,000 to similar what you had down to about 11 per 100,000. And then the subsequent initiation of chlorination showed a drop and virtually eliminated it in our area. And I was wondering if you had any similar breakdown that you might share with us.

Robert Goodings

The information I took this from is from an old publication by the Department of Health of Toronto, and the other information came out of our old files which went back to the 1920s. I am sorry, I can't give you that breakdown. I didn't research that. I was really trying to illustrate how dramatic - or, first of all, how bad the problems were - and how great the chlorination improved it.

DR. MAARTEN SCHALEKAMP

DIRECTOR OF ZURICH WATER SUPPLY
ZURICH, SWITZERLAND

EUROPEAN ALTERNATIVES AND EXPERIENCE

TECHNOLOGIES FOR TREATMENT:
"EUROPEAN ALTERNATIVES AND EXPERIENCE"

Maarten Schalekamp, Dr. sc. techn. h.c. ETH Zurich

Hardhof 9, Postfach
CH - 8023 Zurich / Switzerland

ABSTRACT

In the catchment area of the River Rhine most surface-waterworks possess a seven to ten-stage treatment system. In Switzerland they have a seven to eight-stage facility, i. e. pre-oxidation, micro-flocculation, double layer rapid filtration, neutralisation. ozonisation, granular activated carbon (GAC) filtration, slow filtration and a network protection with chlorine dioxide. The ozone and GAC filter stage show the biggest effect in removing organic substances. Despite the gratifying reduction of organic substances, mainly humic acid, by the use of chlorine, several haloforms are, unfortunately, being produced. If the chlorine is replaced by the chlorine dioxide stage we will obtain chlorite instead of haloforms. Today, new experiences have been gathered with the pre-oxidation stage and the dosage is 0,6 mg Cl_2/l and and 0,3 mg ClO_2/l or vice versa. The Zurich drinking water hardly contains any haloforms and the concentration of chlorite is only 0,01 mg/l and chlorate <0,3 mg/l, which is not harmful to human health. This system of pre-oxidation is reasonable in price and very effective. The removal of organic substances and haloforms through the ozone stage is

very good, however, it produces aldehydes. They can cause a regermination. With an ozone dosage of 5 mg/l the decrease of organics and haloforms is better than with a lower one, but the aldehydes and ketones increase. The GAC treatment stage reduces organics and haloforms and causes the aldehydes to vanish completely.

1. Introduction

The Jungfrau is one of the highest mountains in Switzerland and is in the catchment area of the River Rhine. The white snow which covers this mountain is not as clean today as it was in the past. The cause is environmental pollution (Fig. 1).

Despite becoming more environmentally conscious in the last few years, man has caused a change in the ecological balance of the world. This change can mainly be attributed to the population increase, energy consumption increase and the more intensive agricultural exploitation of the soil (Fig. 2). World chemical fertilizer consumption for instance, has increased nine-fold since 1940 (Fig. 3). If also in future, mankind wants to feel well on the spaceship "Earth", the development of the above-mentioned criteria must not increase beyond the point where the available measures completely cancel them out. Counter-measures, amongst others, are treatment of waste water, fresh water and air, environment protection and population planning.

In Switzerland, the energy consumption rose six-fold since 1940, despite the fact that during the same period the population increased by only about 50 %, i. e. from 4,2 million to 6,2 million. The water consumption of the public works doubled during this time from 0,6 billion to 1,2 billion m^3/year. Chemical fertilizer, the sum of K + N + P, rose seven-fold to 110 000 tonnes per year. The consumption of organic fungizides increased 25-fold since 1954 and rose from 40 to 1 000 tonnes per year. These Swiss figures are also representative for the entire European Continent. In view of these values, it is easily understood why the waters in Switzerland and on the Continent have been adversely affected by the present environmental conditions. The surface waters like lakes and rivers, especially, have been strongly affected.

2. The Environmental Influences on the Waters

As an example we mention the Lake of Zurich which today is not anymore an oligotrophic lake, but an eutrophic one. In the period from 1940 to 1969 the phosphates, at their lowest point, have increased eleven-fold, i. e. 10 to 115 µg P per litre. This is indisputable evidence of the progressive eutrophy. Since a third treatment stage has been taken into operation in the sewage plants of the lower lake, a stagnation of the phosphate values can be noted. Although the content is still 75 µg P per litre (the value expressed in P is three times smaller than the one expressed in PO_4-3).

Even though the oxygen content has essentially improved, on the lake bed it is still at a minimum. Comparison of the organic substances of the sediments of the Lakes Walen and Zurich shows that those of the Lake Zurich, measured on the UV-values are today four times higher than those of the Lake Walen (Fig. 4). The cancer stimulating substances, like phenanthrene, fluoranthene and pyrene, are even 10 times higher (Fig. 5). Control of other Swiss lakes in the last 20 years shows unmistakable eutrophic features.

Also the level of pollution in the Rhine and its tributaries has increased during the past 20 years as the result of the environmental pollution. In the Rhine, the chemical pollution takes precedence, considering that roughly the flow through the Rhine accounts for only 0,2 % of all rivers in the Western world, 20 % of all chemical industries in West Europe are situated in the Rhine area. The treatment of sewage and waste products in the Rhine area is, in spite of all efforts, still insufficient, so that one can judge, how grave the case is.

Although the international cooperation on matters concerning the Rhine is good, the results have been rather meagre. Objective consideration brings one to the conclusion that each Rhine border state must pay more attention to the Rhine, for each state has the necessary legislation dealing with the treatment of waste water. In this way, it is possible to make the Rhine cleaner. A cleaner Rhine is technically feasible, and thus the issue is primarily a political one. That the responsible politicians have assessed the situation correctly, is demonstrated by the many encouraging examples found.

In the opinion of the International Working Party of the Waterworks in the Rhine Catchment Area (IAWR), the Rhine must be judged only against the quality criteria of the water supply services, and not according to whether fish can again live in the river. This is also the reason why the IAWR, working closely together with the German Gas and Water Services Association (DVGW), is publishing the "Rhine

Report 1978", i. e. a guide (with maps) to the quality of the Rhine. In future the Rhine is to be assessed not only in terms of its "bed", i. e. according to the saprobe system; instead, the quality of the Rhine water will be evaluated in terms of the criteria relating to drinking water which means those important for people's health. The aim of this guide is to make clear to the authorities and those who deal with effluent where to set their priorities for conserving the Rhine.

2.1 "Quality Map" of the IAWR for the River Rhine

- According to the IAWR-Report, when appraising the Rhine, the numerical values used must be independent from the water flow at the time of the appraisal.

- The appraisal of waters can only be carried out on parameters for which the relation between water flow and concentration is known and can be mathematically described. Sufficient analysing data for various water flows must be available.

- The parameters to be used for an evaluation should be representative for the type of contamination of the Rhine water and should also have been sufficiently measured. First of all, one should limit the effort to the investigation and presentation of the following parameters (Fig. 6):

  (a) Dissolved Organic Carbon (g/m^3) : DOC
  (b) Ammonia (g/m^3) : NH_4^+
  (c) Oxygen Saturation Deficit (%) : ΔO_2
  (d) Neutral Salt burden expressed in chloride (g/m^3) : ΣNS
  (e) Dissolved Organic Chlorine (mg/m^3) : DOCl

- When evaluating the analyses data, representative concentrations for the long-years average of the water flow as well as for a very low water flow with a probable maximum of concentrations should be determined.

- The assignment of the representative concentrations (average and maximum) to the water qualities 1 - 4 serves merely to illustrate the number values with reference to the concentration density. The basis of the evaluation scale is thereby the long-year experience of the waterworks in the catchment area of the Rhine. The following water qualities are distinguished:

  Water quality 1: practically uncontaminated water
  Water quality 2: moderately contaminated water
  Water quality 3: severely contaminated water
  Water quality 4: excessively contaminated water

- From the water qualities for the five single parameters an aggregate figure can insofar be determined as the highest value for the parameter is used.

The result of the evaluation according to the mentioned criteria, results, for the Rhine, in the quality card shown in Figur 7. From Karlsruhe onwards, for instance, the Rhine receives the note 3 - 4, i. e. the water is severely to excessively contaminated, the reason being mainly the amount of neutral salts in the water.

3. The Water Treatment Processes of the Water Plants on the River Rhine and in its Catchment Area

The possibilities to improve the drinking water treatment are not unlimited. At the waterworks on the Lower Rhine for example practically all possibilities for water treatment have been utilized. They consist of river bank filtration, ozonation, multi-layer filtration, GAC-filtration, neutralization and safety chlorination. The operating period of the GAC-filter of these works was 13 to 14 months in 1966, in 1974 only six weeks and through the improvement of the water quality of the Rhine with regard to DOC and lignin sulphonic acids it is today (1979) three to four months (Fig. 8). Many waterworks on the Continent have done everything in their power during the last decade to supply first-class drinking water. Three examples shall clarify this:

In Weesperkarspel, Netherlands, a waterworks is in operation since 1886, with pre- and slow sand filtration, whose raw water comes from various lakes as well as from the River Rhine. At the end of the treatment, the water was chlorined and this quality sufficed in those days. In consequence of the change in the raw water quality the treatment for the water supply of Amsterdam had to be constantly adapted in the last years, so that today a very complicated treatment system must be used, in order to provide drinking water of the required purity (Fig. 9). This process consists of the following nine treatment stages: mixing of the Rhine water with water from the Betune Polder and subsequent cleaning in a self-cleaning pool, 1. rapid filtration, ozonation, GAC addition in powder form, coagulation, 2. rapid filtration, slow sand filtration, deacidification and safety chlorination.

For a second example let us look at the water supply of Wiesbaden, Federal Republic of Germany. In former years, river bank filtration was sufficient. Through the contamination of the Rhine, the capacity of the wells was successively and perceptibly reduced, so that artificial ground water enrichment had to be initiated. Today, drinking water in Wiesbaden is treated in ten stages: aeration, sedimentation, break point chlorination, flocculation with $FeCl_3$, rapid filtration, GAC filtration, replenishment of ground water by infiltration via well and basin, aeration, slow sand filtration and safety chlorination (Fig. 10).

The third example is Zurich, where up to 1971 two process stages for the treatment of lake water were in use, either rapid filtration and chlorination or rapid and slow sand filtration. Within five years the difficulties increased to such an extent that the water treatment system in operation hitherto could not be justified any more. Therefore, the following, eigth-stage process had to be used in the two lake water plants at Zurich: pre-chlorination, flocculation, rapid filtration, neutralization, ozonation, GAC filtration, slow sand filtration and safety chlorination with chlorine dioxide (Fig. 11).

4. The Water Treatment Process of the Lake Water Plants in Switzerland

Ten lakes and the River Rhine are used for drinking water supply in Switzerland (Fig. 12). Of the total of 36 lake water plants, alone 24 take their water from the Lakes of Constance, Zurich and Leman. With reference to the various lakes we have the following picture:

Lake Constance, Swiss side (German side 10 plants	8 plants
Lake Zurich	10 plants
Lake Leman, Swiss side	7 plants
Lake Lucerne	3 plants
Lake Neuchâtel and Lugano (2 plants each)	4 plants
Lac du Brêt, Lakes of Murten, Sempach and Biel (1 plant each)	4 plants
	36 plants

Of the river water plants, two must be mentioned, both situated on the banks of the River Rhine. They are the works of Hardwasser Ltd. and of the City of Basle. Furthermore, there are five large industrial water supply plants, two on the Rhine, two on the River Rhone, one on the River Saane, as well as a number of plants on smaller lakes. Figure 13 shows the problems which existed in the Swiss lake water plants. As can be gathered from Figure 14, it is not only legislation which is important for water protection, but also the measures initiated by the waterworks themselves.

Of a total of 36 Swiss lake water plants (Fig. 15), 17 have, in 1978, adopted the rapid filtration with subsequent ozonation and chlorination process. In six plants the treatment process is as follows: pre-chlorination, multi-layer rapid filtration with GAC and sand, subsequent ozonation, chlorination or chlorine dioxide treatment. A further six plants possess the pre-chlorination, multi-layer rapid filtration with sand and pumice of anthracite, ozonation, GAC filtration and chlorine dioxide treatment. The last seven plants possess the following treatment process: pre-chlorination, flocculation, multi-layer rapid filtration (sand and pumice), neutralization, ozonation, GAC filtration, chlorine dioxide treatment.

The plants at Horw (Lake Lucerne), Rolle (Lake Leman), St. Gall (Lake Constance), Zurich-Moos and Zurich-Lengg (both Lake Zurich) all have a slow sand filtration stage prior to the chlorine dioxide treatment. The City of Basle river water plant Lange Erlen, has a rapid filter stage with chlorination prior to percolation. The river water plant Hardwasser Ltd. operates according to the following process: flocculation with sedimentation, rapid filtration and percolation (slow sand filter).

4.1 The Various Future Process Chains

In future the following treatment process will be employed on Swiss lake water plants:

> pre-chlorination, flocculation, double-layer rapid filtration with sand and pumice, neutralization, ozonation, GAC filtration, slow sand filtration and chlorine dioxide treatment.

The foregoing indicates that on practically every Swiss lake which is being used for drinking water production, the new treatment technique is already in operation or will shortly be in operation. The same tendency can be discovered in the river water plants, with the exception, that flocculation with sedimentation is foreseen. The question now arises, why and how these processes are used in Switzerland. In a short outline they can be described as follows:

1st stage: pre-chlorination of raw water

In the catchment head of the lake intake pipe the raw water is chlorinated with 1 mg Cl_2/l. The pre-chlorination of the raw water is to be looked upon as a proper stage. On the one hand, this particular stage keeps the raw water facility up to the rapid filter absolutely clear (Fig. 16) of any algae and Dreissena Polymorpha Pallas larvae deposit, on the other hand, it reduces the dissolved organic substances in the water by 6 to 20 (Fig. 17). This reduction occurs, if one or several milligrammes Cl_2 per litre water are added. However, if only 0,5 mg Cl_2 are added, the reduction can almost not be ascertained. Also the DPP cannot be destroyed with any certainty. Tests have shown that an addition of 1 mg and a rest chlorine content of 0,5 mg/l in the rapid filters will eliminate the DPP within 13 days. It is known that the larvae require 14 days to pass through the filter, so that the elimination time is just sufficient (Fig. 18).

Chlorination also brings an improvement of the colour of the water. In place of the greenish appearance it has a blue tint. The halogen compounds formed by chlorination amount to only 10 - 15 µg/l and, it is true, they are as yet hygienically harmless, but unwanted. If this process has been changed to chlorine dioxide, you will get chlorites instead of haloforms, but chlorites are also unwanted (Fig. 19).

Today, new experiences have been gathered with the preoxydation stage and the dosage is 0,6 mg Cl_2/l and 0,3 mg ClO_2/l in the lake water works. The Zurich drinking water hardly contains any haloforms and the concentration of chlorite is only 0,01 mg/l and chlorate <0,3 mg/l which is not harmful to human health. This system of preoxydation is reasonable in price and very effective (Fig. 20).

To ensure that the drinking water is of impeccable quality, the bank filtrate resp. the groundwater require treatment. To inactivate possibly present viruses and to prevent excessive algae development in the enrichment basins, the bank filtrate is preoxidized whereby the dosage amounts to 1/3 chlorine dioxide and 2/3 chlorine, a total of 1,2 mg/l. A sole treatment with chlorine results, in conjunction with the organic substances present in the Limmat bank filtrate DOC about 0,5 mg/l), in the formation of up to 5 µg/l haloforms. A sole dosage of chlorine dioxide of 1 to 1,5 mg/l ClO_2, a concentration having a satisfactory algaecide effect, does practically not produce any haloforms, but after a prolonged contact time 0,1 to 0,2 mg/chlorite are formed in the bank filtrate. This chlorine compound, just as the haloforms, are not wanted in the drinking water. Therefore, the two oxydation processes are also combined. For instance, combining 0,8 mg/l chlorine with 0,4 mg/l chlorine dioxide results in five times fewer haloforms in the bank filtrate (Fig. 21) (resp. up to 1 µg/l) and less than 0,1 mg/l chlorite. These values are still lower in the drinking water obtained from the horizontal filter wells. This is the reason why both oxydizing agents are being used (Fig. 22).

2nd stage: flocculation filtration

Rapid Filtration

Before the chlorinated water reaches the rapid filter, a flocculant and a flocculant aid are added. Tests have established that a flocculant addition of 1,5 mg, be it aluminium or iron sulfate, together with a flocculant aid, in function of time, the optimum will be obtained. The cleaning effect on the phytoplankton larger than 20 µm and detritus larger and smaller than 20 µm is 6 %, i.e. without micro-flocculation 92,5 % are kept back and with micro-flocculation the removal amounts to 98,5 % (Fig. 23). The cleaning effect on the phytoplankton smaller than 20 µm is considerably better; without micro-flocculation 50 % are still present in the rapid filter, with micro-flocculation only 28 %. The target, however, is to remove also those 28 % from the drinking water (Fig. 24). Therefore, other filtration stages must come into use after the rapid filtration, in order to further reduce the above percentage. The addition of flocculants causes, besides the above-mentioned cleaning effect, a partial precipitation of the phosphates which serve as food for the plankton and germs. The efficient filtration of the plankton prevents the development, in the drinking water pipes, of higher organisms such as oligochaeta, nematodes, ostracodes, asellus, nauplius, cyclops and canthocamptus.

Multi-Layer Filtration (Figs 25 and 26)

By using the multi-layer filtration with sand and pumice, a six to eight times longer operation with the same cleaning effect is obtained. When one knows that, at peak times, many lake water plants must wash their rapid filters twice a day, the multi-layer filtration is a decided improvement. Especially important is the fact that despite the longer operation time the efficiency of the cleaning remains the same. This process is of great economical advantage because considerably less scavenging water is required.

3rd stage: neutralization

After filtration the water is neutralized, i.e. deacidified (Fig. 27). Most of the lakes have lost their carbon dioxide balance. The pH-value should be about 8,2, however, it is according to lake and intake depth 7 to 7,8. Flocculation with aluminium sulfate also reduces the pH-value somewhat. It must, therefore, be corrected upward to prevent corrosion in house installations and water pipelines. The value will be corrected to within 10 % above pH equilibrium. The waterworks of St. Gall, Basle and Zurich were very successful with this type of neutralization. The corrosion of the insides of the pipelines is now under control. Comparison tests at the Swiss Federal Institute for Material Testing (EMPA) between neutralized lakewater and non-neutralized groundwater are shown in Figur 28.

4th stage: ozonation

Swiss people love good air and cleanliness. They are possibly spoilt by the fresh mountain air. Air which contains a minute quantity of ozone gives the impression of being fresh mountain air when breathing it. This is maybe one of the reasons why Switzerland is such an ozone-favouring country. The fact that 24 plants per million inhabitants are in operation speaks for itself. This is more than twice the number of plants that France possesses and it brings Switzerland to the first place in the world (Fig. 29).

First, we will give an answer to the following questions: "Why use ozone? And in what concentration?" In order to better answer this question, the effect of a dosage of 1 resp. 5 mg of ozone per litre will be compared. Most of the results refer to investigations of lakewater from Switzerland and cannot be used otherwise without necessary corrections. Just as one can drink alcohol of various concentrations (Fig. 30), so it is also possible to ozonize in smaller or larger concentrations. If one wants to stay fresh, a slightly alcoholic drink would be just right, to prevent a cold, an alcoholic drink of a higher concentration is called for.

How the foregoing can be adapted to ozone is the subject of this paragraph. First of all, the behaviour of bacteria. Whether Lake Zurich water is treated with 1 or 5 mg O_3 makes no difference to the germ development (Fig. 31). After three weeks, the first germ development starts and from the fourth week on, the number of germs is between 10^4 to 10^5 per millilitre. The regermination in water which, prior to dosing with 1 resp. 5 mg O_3/1, has been chlorinated with 1 mg/l starts from the sixth week onwards instead of from the third week.

Secondly, it is important to know, how the viruses behave. Figur 32 shows that according to the studies of Katzenelson and Shuval (1975) the inactivation of viruses for the various ozone concentrations of 0,3, 0,8 resp. 1,5 mg O_3/l is similary effective.

In conclusion, it can be said that in regard to the destruction of bacteria and inactivation of viruses, in water of not too high a degree of contamination, a higher concentration of ozone than 1,0 to 1,5 mg/l is not necessary.

The decolouration through ozone in various concentrations can be seen in Figur 33. With an ozone concentration of 1,0 mg/l the colour intensity is reduced by 50 % and with a concentration of 5,0 mg/l by 70 %. For a better decolouration, a higher ozone concentration could be of use.

Contrary to the tests with DOC, where no alterations occured through ozone of various concentrations, the $KMnO_4$ decreased by 14 % at a dosage of 1,0 mg O_3/l and a decrease of 18 % at a dosage of 5,0 mg O_3/l was noted. The initial values of the UV-extinction values (Fig. 34) are reduced by 33 % at a dosage of 1 mg O_3/l and by 57 % at a dosage of 5,0 mg O_3/l. This means that, if a lot of humic acid has to be removed, a higher ozone dosage will easier reduce it.

Ozone is an excellent agent to remove the taste of phenol or trichlorophenol (Fig. 35). 1,0 mg O_3/l reduces 100 µg phenol resp. 500 µg trichlorophenol. 5,0 mg O_3/l reduces 500 µg phenol resp. 2 500 µg trichlorophenol. It is of great advantage to be able to carry out a high ozone dosage when a phenol accident has occurred.

On the one hand, ozone strongly reduces haloforms and, on the other hand, it produces large amounts of aldehydes and ketones. Let us consider the aldehydes (Fig. 36). Laboratory tests at Zurich Waterworks confirm the values of Grob with a reaction time of from 10 minutes up to one day the concentrations of the aldehydes will be 8,5 times larger at a dosage of 1 mg O_3/l and 30,6 times larger at a dosage of 5 mg O_3/l. Through their decay, aldehydes and ketones produce corresponding acids, which serve as food for germs. Therefore, a higher concentration of ozone prior to a biological treatment stage, should be of advantage. If the ozone is used as a last stage, the concentration should be as low as possible, because of the regermination.

Figur 37 shows quite clearly that ozone during a very long reaction time reduced the halogene compounds by 31 % at a dosage of 1,0 mg O_3/l and by 77 % at a dosage of 5,0 mg O_3/l. This long contact time is possible, if there is an intermediate reservoir after the ozonation, as is the case at the Lake Constance Waterworks for instance. With a reaction time of 10 minutes - the plants at Lengg and Moos operate like that - the haloforms at 1 mg O_3/l are practically reduced for the same amount, at 5 mg O_3/l by 47 %, which means less than is the case with the longer reaction times.

Looking at the flocculation effect (Fig. 38) during ozoning of 1,0 to 5 mg O_3/l, one can say that the optimum lies between 1,0 to 1,5 mg O_3/l and that at 5,0 mg O_3/l the opposite of a flocculation occurs. Before the selection of the proper dosage an exact analysis should be made what the ozone will be required for. A high dosage can in many cases be of great advantage, however, in other cases it can be of disadvantage. Figur 39 shows quite clearly that a higher ozone concentration dosage is of advantage to reduce the phenol compounds and haloforms as well as improving the UV and colour values. However, it negatively influences flocculation and, if no refiltering takes place, also the regermination. For the destruction of the bacteria and the inactivation of the viruses as well as for flocculation, no increased dosage concentrations are necessary. In case of a breakdown, for instance when a phenol accident occurs, it would be of advantage to be able to increase the dosage.

At many waterworks in the world, peak consumptions which are twice as high as the normal average requirement occur only during one to two weeks per year. It is, therefore, possible during a breakdown, which will hardly occur at peak times, to dose higher ozone amounts by reducing the plant capacity. Every plant manager should construct his ozone units in such a way as to be able through a reduction of the plant capacity, to dose more ozone. This is especially valid, if he operates a facility which has been designed for normal dosage. We are of the opinion that, when using ozone, the concentration in the water and in the exhaust air must continually be monitored.

For those who do not posses an ozone unit, they should realize the following: Ozone can do a lot, but not everything. Ozone has saved many plant managers from ultimate disaster.

Today, no water surface treatment plant should be built without an ozone stage (Fig. 40).

5th stage: granular activated carbon (GAC) filtration

In order to remove the excess chlorine and ozone from the water, it is passed over a GAC filter. The GAC operating speeds vary between 10 and 20 m/h at a height of the filter bed of 1,20 m. The GAC filters usually rest on a bed of sand of about 50 cm in thickness (Fig. 41). Besides the removal of excess chlorine and ozone, the GAC filter extracts from the water large amounts of organic substances (Fig. 42).

In one of the waterworks for instance it has been discovered that the uppermost layer, consisting of Pittsburgh F 400, after an operation of two months, showed already a load of 37 g/kg. At the beginning, the new GAC filter had a load of 4 g/kg. After three months of operation the load was already 63,5 g/kg and after seven months of operation the highest load, 68,2 g/kg was measured. These tests have clearly shown that without GAC filtration many more organic substances would still be present in the drinking water. Other tests have shown that these substances are absent from good, i.e. unburdened spring water. One of the main responsibilities of a waterwork is the provision of water of impeccable quality, be it spring, ground or surface water. For that reason, GAC filtration is absolutely necessary for the purification of surface water in Switzerland.

Measurements have revealed that after six months, if no ozonation occurs, and after three years, if a pre-ozonation takes place, the GAC filter layer is loaded with organic substances, so that a renewal resp. a reactivation becomes necessary (Fig. 43), that means that the ozone stage decreases the

the costs of the GAC stage very much! The reactivation is carried out by means of the so-called "fluid bed process", system Norit. In this furnace were reactivated, besides the GAC Norit ROW 08 Super, which emerged from the latest comparison tests as the best GAC, also Norit PKST, a light GAC and Pittsburgh 400. The losses were only 50 % as against the customary reactivation process. The GAC Norit PKST for instance was only loaded with 28 g/kg; the fresh GAC showed a load of 5 g/kg and the reactivated GAC only 8 g/kg (Fig. 44). The GAC loss amounts to only 3,5 % by the first reactivation and 10 % by the second, measured from the filter via the silo, furnace, silo back to the filter. The results show that the efficiency of the reactivation can be classed as fine.

We believe that there are three important criteria for changing the GAC first and second , if the halogenes (Fig. 45) and UV (Fig. 46) of the drinking water are higher than the permitted level. Third, if the upper layer of the GAC in the filter is loaded to capacity (DMF + Dioxan extract) and the bottom layer is loaded with 70 % of the maximum of the upper layer (Fig. 47). Although three and four digit germ figures occurred after monthly backwashing in the various GAC filters of the Zurich test plant, it was then already discovered that after weekly backwashing the germ figures were four times less. In today's operating, GAC filters not higher than two-digit germ figures can be discovered, i.e. 0 to 5 per cm^3; however, this is only valid, if the filters are backwashed at least every two days by air and water. If the cleaning occurs at longer intervals and without air, the germ figure rises again, as experience has proved in Zurich (Fig. 48).

6th stage: slow sand filtration

In Switzerland slow sand filtration is still in use at five lake water plants. This is a process which becomes more important for the artificial groundwater enrichment. Tests have shown that with an effective pre-treatment the slow filtration can in future be operated at an average speed of 15 m/day instead of the now usual 3 to 7,5 m/day. It was discovered in actual operation that, because of a thorough pretreatment, the operating period without cleaning is three years. Formerly, the filters had to be cleaned every six to nine months. The cleaning effect with reference to the filtration of the phytoplankton detritus as well as to the elimination of the germs is equally efficient, if the slow sand filter is operated slowly or rapidly (Fig. 49). Investigations have established that the slow sand filter, with regard to the bacteriological and biological cleaning effect, has to be clearly classified as a spatial filter. It is only a surface filter with reference to the mechanical cleaning. Despite the higher speed, a slow sand filter with the same standard of water treatment is not more expensive than a rapid filter, not counting the price of land.

7th stage: pipeline protection

The addition of chlorine dioxide does not anymore serve the water treatment, but only as pipeline protection, so that the water in the supply and distribution network remains hygienically perfect (Fig. 50). The dosage is only 0,05 mg ClO_2/l, so that there are no difficulties with chlorite and chlorate.

Figure 51 shows the increase resp. decrease of the halogenized hydrocarbons during the treatment stage with and without ozone. It is quite obvious that without ozone, as a result of the chlorine drift, the halogenized hydrocarbons increase up to the GAC filtration and are subsequently heavily reduced after this stage and the slow filtration. When ozoning takes place, the halogenized hydrocarbons do at least not increase anymore after ozonation, they are even partly reduced, so that in any case in the end a better result is obtained by the use of ozone.

How excellent the cleaning effect of the above-described treatment process is can be gathered from the following: the organic substances are reduced by 90 %, this means that the UV-extinction, measured at 254 nm, amounts to 0,040 in the raw water and 0,004 in the drinking water. How good the water treatment is can be gathered from Figure 52. On the right is the raw water and on the left the drinking water.

The high standard of the water treatment processes of the Swiss lake water plants also extends to the construction and technical realization. Furthermore, because of the shortage of personnel, most waterworks operate fully automatic. A remote control centre monitors, controls and evaluates the operation (Figs 53 and 54).

5. Outlook

It can be seen from this article that the water supply plants have done all in their power to produce good, clean drinking water. A further purification of the drinking water is hardly possible, the limit of what can be done has been reached. On the waste water side, however, more can and must yet be done. The endangerment of the future of the continental population can without doubt be repelled, however, it will require sacrifices. The drinking water supply plants of the Continent have done their share. It is now up to the waste water treatment plants to do theirs, so that our children, too, will be able to drink good, clean water (Fig. 55).

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- Expansion of the Lengg Lake Water Works (from GWA 1975/9 Swiss Gas and Water Industry Association, 41 authors)
- Meeting for the Treatment of Surface Water (from GWA 1977/1 Swiss Gas and Water Industry Association, 22 authors)
- Cleaner Rhine - A Political Case; M. Schalekamp (A Water Research Centre Conference in Oxford "River Pollution Control", Paper 3, Serie 1, April 1979)
- Experience in Switzerland with Ozone, Particularly in Connection with the Neutralization of Hygienically Undesirable Elements Present in Water; M. Schalekamp (AWWA 97th Annual Conference Proceedings 1977, Anaheim)
- Working Conference on Modern Remote Control Techniques and Process Control for Gas and Water Supplies (from GWA 1978/9 Swiss Gas and Water Industry Association, 23 authors)
- Threatened Water - Endangered Future with Reference to the River Rhine; M. Schalekamp (from GWA 1979/4 Swiss Gas and Water Industry Association)
- Granular Activated Carbon (GAC) in the Treatment of Drinking Water "Swiss Experiences"; M. Schalekamp (IWSA Specialized Conference on the Use of Activated Carbon in Water Treatment, Brussels, May 1979)

- Proposal of the ISWR for Evaluation of Water Quality with Reference to the Rhine (7th IAWR Working Conference at Basle, May 1979, from GWA 1979/9 Swiss Gas and Water Industry Association and from the Annual Report '78)
- The Use of GAC Filtration to Ensure Quality in Drinking Water from Surface Sources; M. Schalekamp (Journal AWWA 1979/11)
- Comparisons between two Ozone Plants with Normal and Increased Frequency as well as of the Effect between a Dosage of 1 mg resp. 5 mg of O_3 per litre (from Ozone Science and Engineering, Vol. 1, No. 2, 1979)
- Destruction of Ozone Excess by Thermic Catalytic Methods; M. Schalekamp (from Ozone Science and Engineering 1980)
- The most up-to-date Groundwater Management by Means of Process Computers explained on the Example of the Groundwater Plant Hardhof Zurich/Switzerland; Separate Print No. 1011 Swiss Gas and Water Industry Association, September 1983

1

Switzerland-Jungfrau: 4158 m

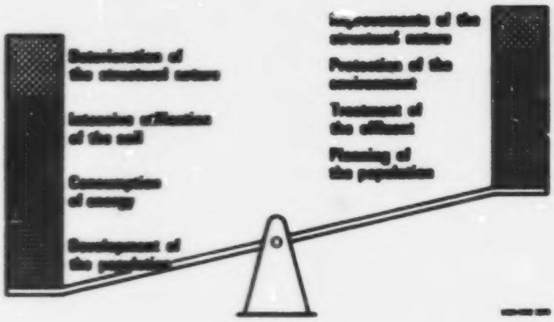
1

Switzerland-Jungfrau: 4158 m

Causes of pollution

Counter-measures

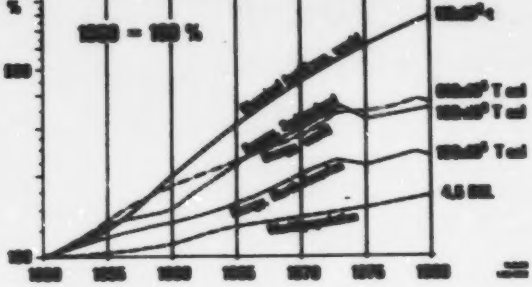
2


Deterioration of the structural nature
Intensive utilization of the soil
Consumption of energy
Development of the population
Improvements of the structural nature
Protection of the environment
Treatment of the effluent
Planning of the population

3

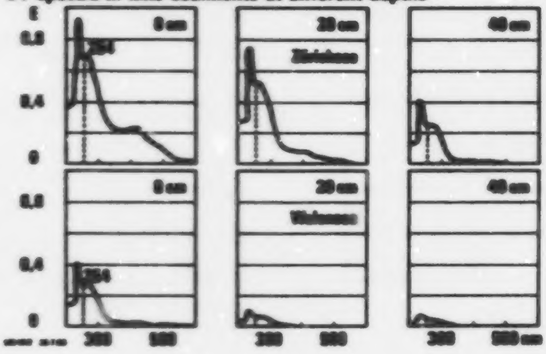
Growth of world population

Consumption of fertilizer for world and of energy for world, North America and Switzerland in %



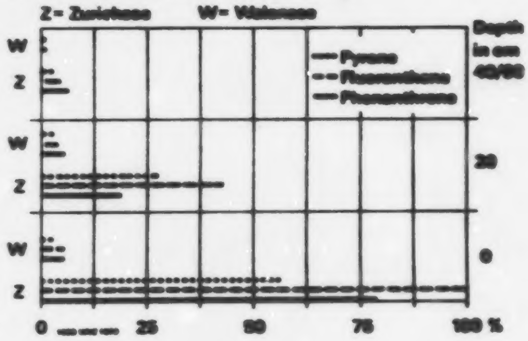
UV spectra in lake sediments at different depths

4



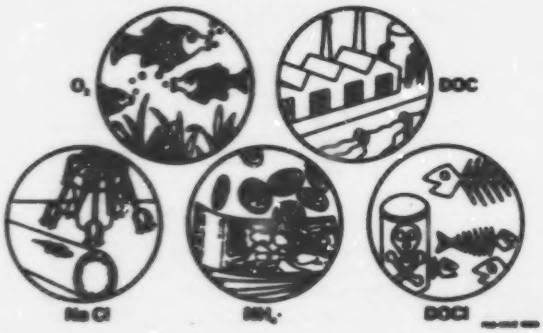
PAH in sediments of different ages

5

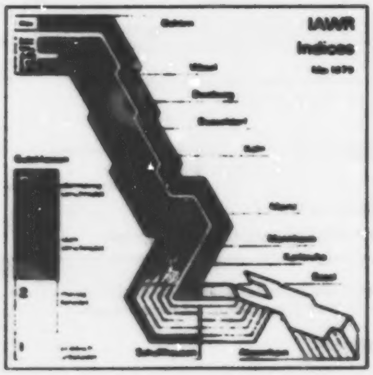


The five water quality criteria of IAWR

6


O₂
DOC
Na Cl
NH₄
DOCl

7

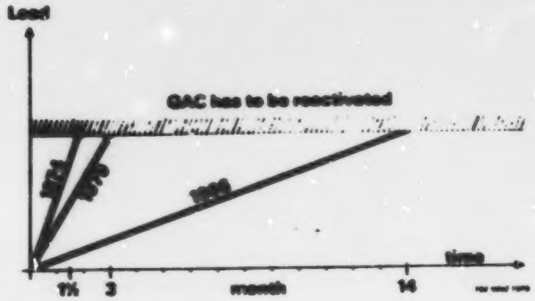

IAWR
Indices

Vorschlag der IAWR
zur Bewertung der Gewässerqualität am Beispiel des Rheins

Proposition de l'IAWR
pour l'évaluation de la qualité des eaux dans le cas du Rhin

Proposal of the IAWR
for evaluation of water quality with reference to the Rhine

Lower Rhine GAC reactivation cycle 8



Treatment process at Wesperkaspel Lake Waterworks, Amsterdam 9

Yesterday

- Primary filter
- Slow filter
- Chlorination

Today

- Mixing
- Rapid filter
- Ozonation
- Activated carbon (powder)
- Coagulation
- Rapid filter
- Slow filter
- Deacidification
- Safety chlorination

Treatment process at the Rhine Waterworks, Wiesbaden 10

Yesterday

- Bank filtrate
- Chlorination

Today

- Aeration
- Sedimentation
- Break point chlorination
- Flocculation with $FeCl_3$
- Rapid filter
- Activated carbon filter
- Replenishing basin
- Aeration
- Slow filter
- Safety chlorination

Treatment process at the Lake Waterworks, Zurich 11

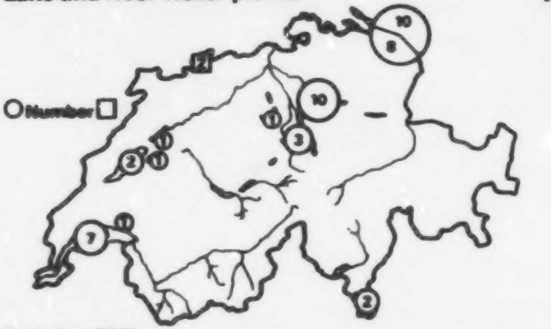
Until 1971

- Rapid filter
- Slow sand filter
- Chlorination

Today

- Pre-chlorination
- Micro-flocculation
- Double layer rapid filter
- Neutralization
- Ozonation
- Activated carbon filter
- Slow sand filter
- Chlorine dioxide

Lake and river water plants 12



Total CH = 36/2

Difficulties in treating lake water since 1960 13

1. Inflow of phenol
2. Rapid increase in germs
3. Recontamination of network
4. Increase in nanoplankton
5. Rapid clogging of filters
6. Increase in phosphates
7. Oxygen depletion
8. Corrosive carbonic acid
9. Mussels: Dreissena polymorpha Pallas
10. Fauna in the filters
11. Flavour problems
12. Trace elements
13. Water pollution
14. etc.

A. For government states and cities 14

1. Fighting against the cause of pollution by making laws and using them for the environment protection
2. Use of the laws for water protection and construction of water treatment plants until 1982

B. For the water supply and industry

1. Saving of water
   - recycling processes in industry
   - progressive water tariffs related to consumption
   - public relations
   - use of the most up-to-date installations, mixing batteries, baths with fixed shower attachments etc.
2. Improve water treatment

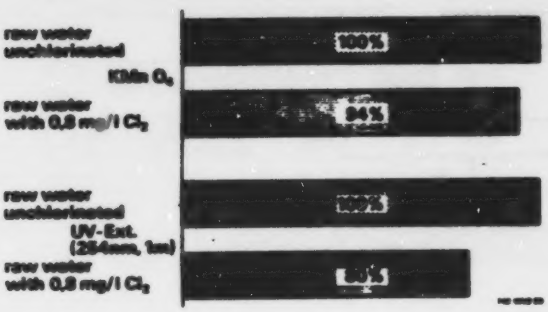
Water treatment process of 36 plants in Switzerland 1982 15

	Rapid-filter	Pre-chlorination	Pre-chlorination	Pre-chlorination
	Ozonation or chlorination	Double layer rapid filter with GAC	Double layer rapid filter	Micro-flocculation
		Ozonation or chlorination or chlorine dioxide	Ozonation	Double layer rapid filter
			GAC-filter	Neutralization
			Chlorine dioxide	Ozonation
				GAC-filter
				Slow sand filter
				Chlorine dioxide
Works	25 %	25 %	25 %	25 %
Production	2 %	8 %	10 %	80 %

16

Left: Pipe surface without chlorine
Right: Pipe surface with chlorine

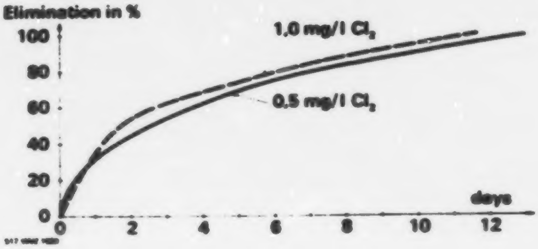
Decrease of KMn O_4 and the UV-Ext. by Cl_2 in % 17



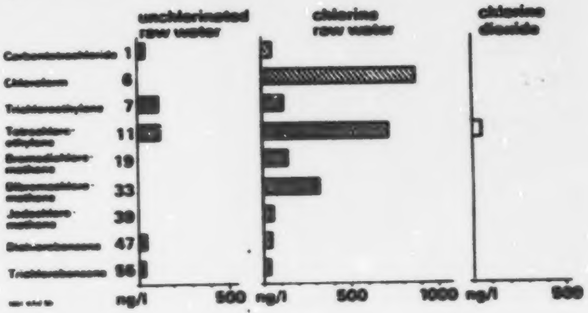
Elimination of Lake of Constance - DPP - larvae 18

in raw water from the Lake of Zurich.

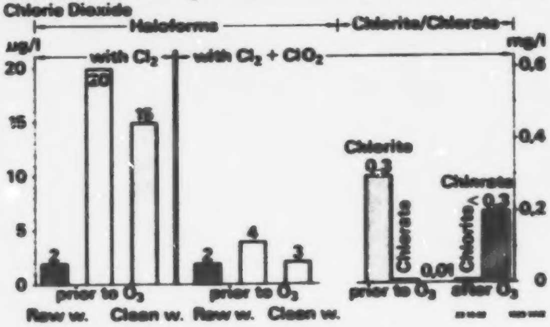
(based on Dr. Bossnegger)



Formation or elevation of halogen compounds by chlorine and chlordioxid 19



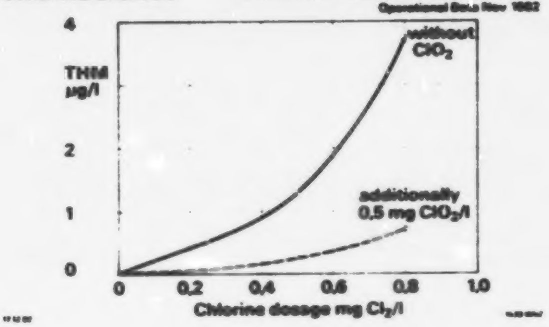
Formation of Haloforms as well as of Chlorite and Chlorate during Oxidation with Chlorine or Chlorine and Chlorie Dioxide 20



Hardhof Pre-oxidation with Chlorine and Chlorine Dioxide 21

Formation of Trihalomethane (THM)

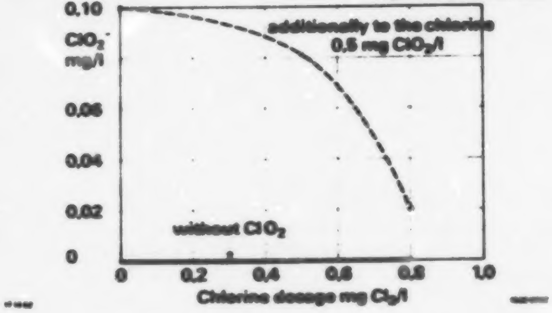
Operational Data Nov. 1982



Hardhof Pre-oxidation with Chlorine and Chlorine Dioxide 22

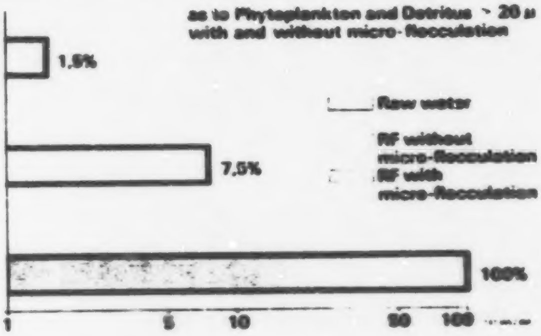
Formation of Chlorite (ClO_2^-)

Operational Data Nov. 1982



Cleaning effect of the double layer rapid filter 23

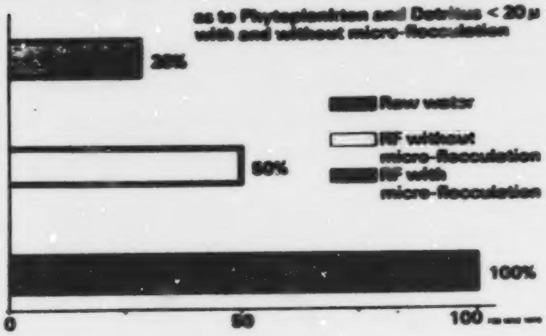
as to Phytoplankton and Detritus ~ 20 µ with and without micro-flocculation



Cleaning effect of the double layer rapid filter

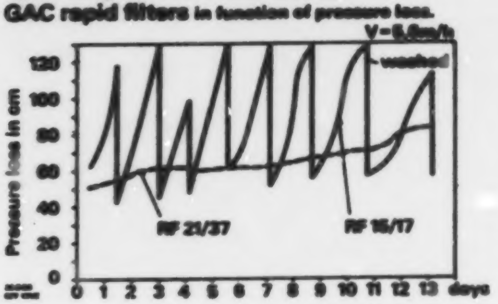
24

as to Phytoplankton and Detritus < 20 μ with and without micro-flocculation



Operating time of 1-and 2-layer GAC rapid filters in function of pressure loss.

25



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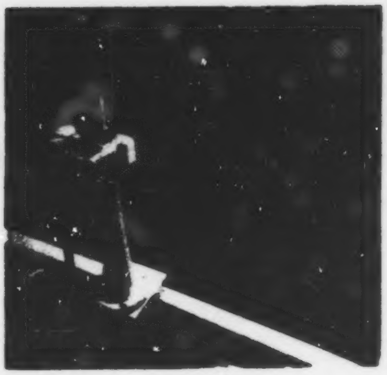


Double

layer

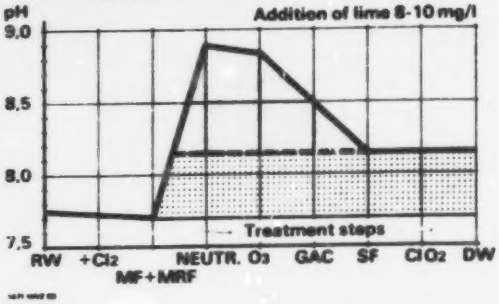
rapid

filter

Lengg

pH during water treatment process in WW Lengg Zurich

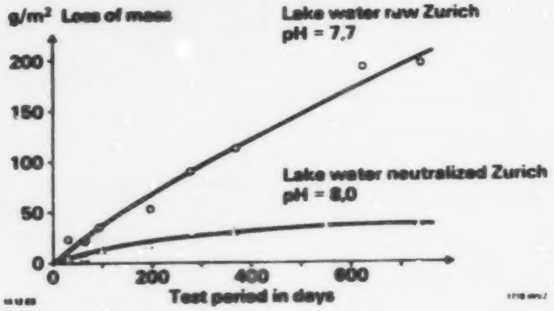
27



Internal Corrosion at galvanized Steel Pipes

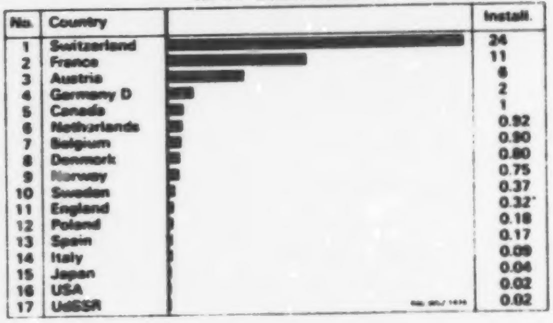
28

Influence of pH-values



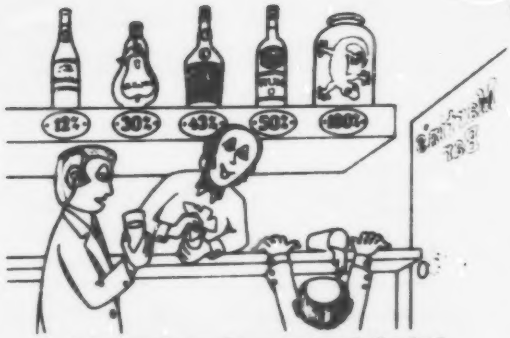
Ozone-plants per 1 mio. inhabitants in 17 countries.

29



No.	Country	Install.
1	Switzerland	24
2	France	11
3	Austria	6
4	Germany D	2
5	Canada	1
6	Netherlands	0.92
7	Belgium	0.90
8	Denmark	0.80
9	Norway	0.75
10	Sweden	0.37
11	England	0.32'
12	Poland	0.18
13	Spain	0.17
14	Italy	0.09
15	Japan	0.04
16	USA	0.02
17	UdSSR	0.02

30

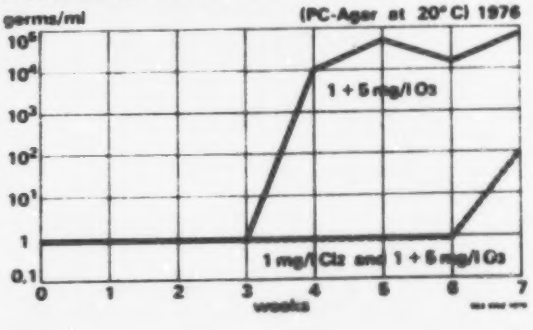


Comparison of percents of alcohol

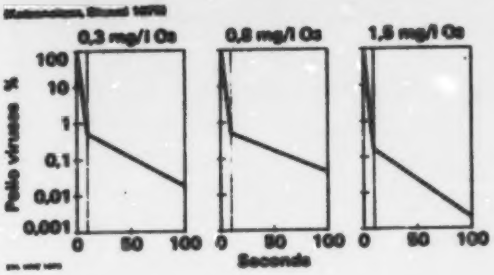
Germ development at 9° C

31

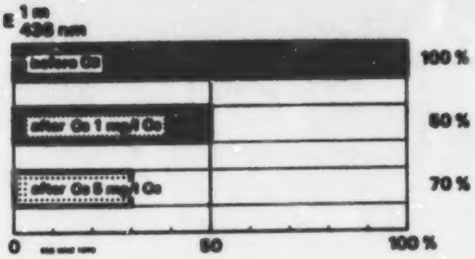
in O3-as well as in Cl2 + O3 water



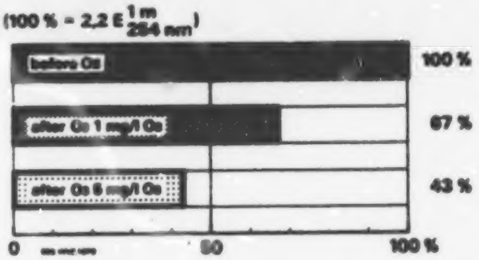
32 Inactivation of the viruses at various ozone-concentrations as a function of time



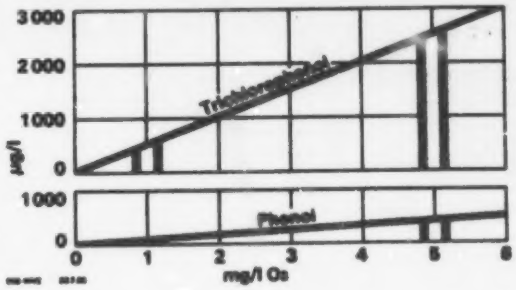
33 Decolouration through ozone at various concentrations



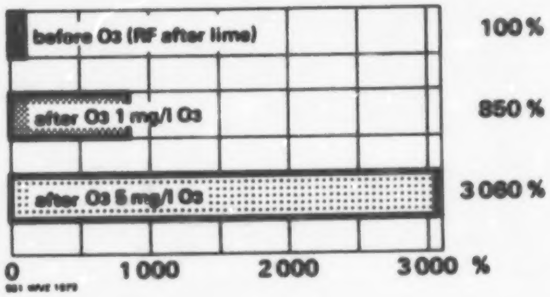
34 Decrease of the UV-extinction through ozone at various ozone concentrations



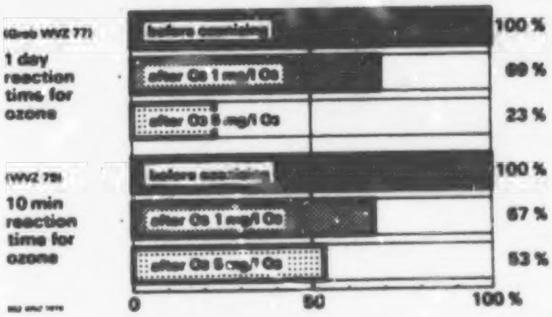
35 Decrease of trichlorophenol and phenol through ozone as a function of supplemental rates



36 Increase of Aldehydes

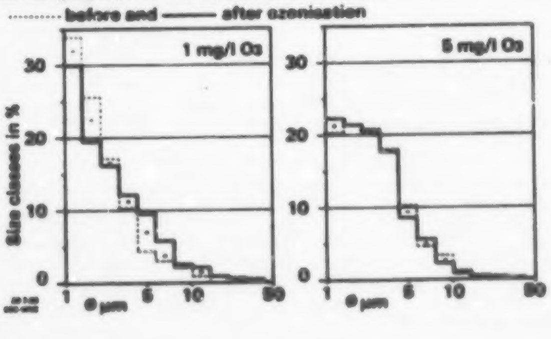


37 Decrease of the Haloforms



38 Flocculation effect

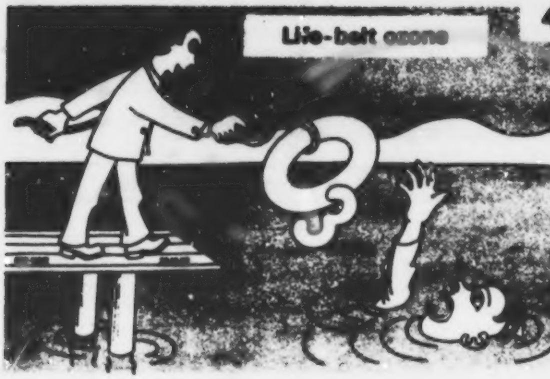
Change of particle quantity and size



39 Effect of O_3 on various parameters

	1 mg/l	5 mg/l
Phenol	••	•••••
Viruses inactivation	•••••	•••••
Haloforms after 24 h influence	••	••••
Haloforms after 10 min. influence	•	••
UV-extinction 254 nm	••	•••
Colour	••	•••
KMn O_4	•	••
Flocculations	•	–
Regermination	––	––
Aldehydes	––	––––

•	positive	–	negative
•••	very good	–––	poor
•••••	excellent	–––––	very poor



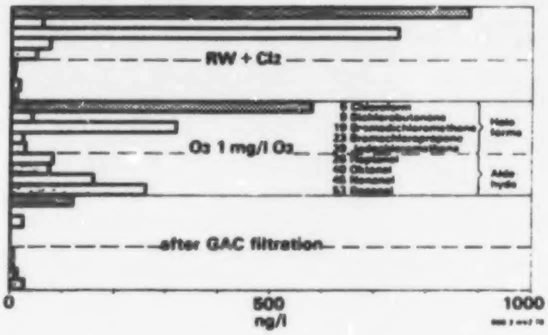
40

41

Sand and GAC of the double layer GAC filter

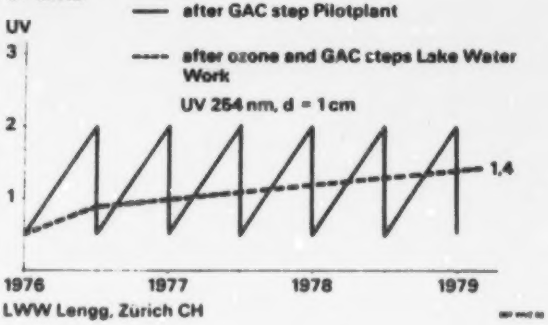
Organic contents GC

42



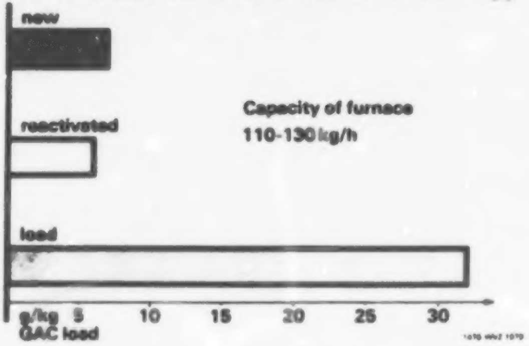
UV extinction in drinking water in function of time

43



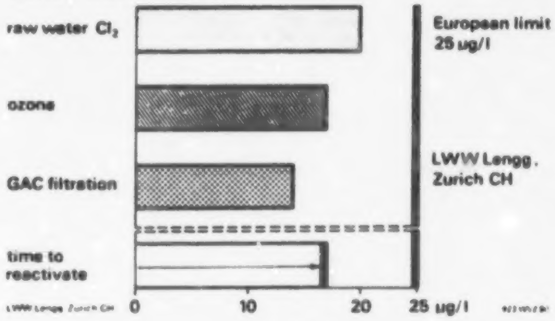
Effectiveness of GAC-reactivation Zurich Lengg

44



Halogenes in raw and drinking water of Zurich water supply

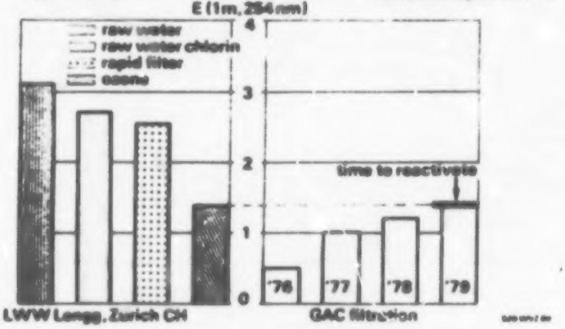
45



Variation of UV-Extinction during water treatment

46

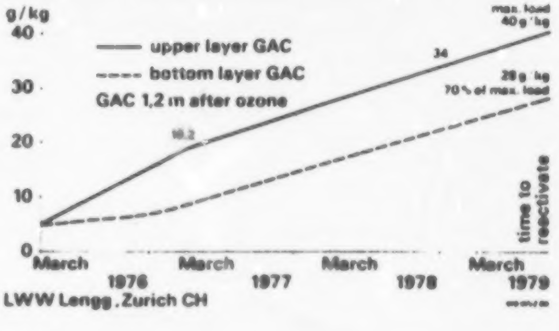
Yearly average 1976/79



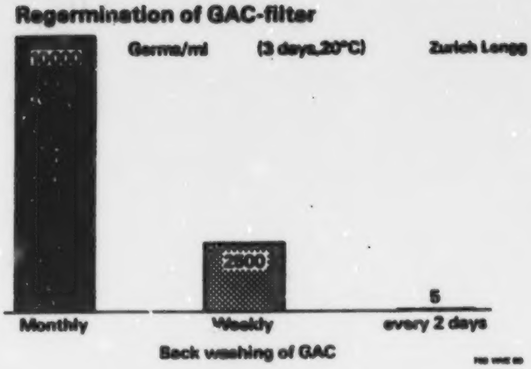
Load of upper and bottom layer GAC

in g/kg DMF · Dioxan extract as a function of time

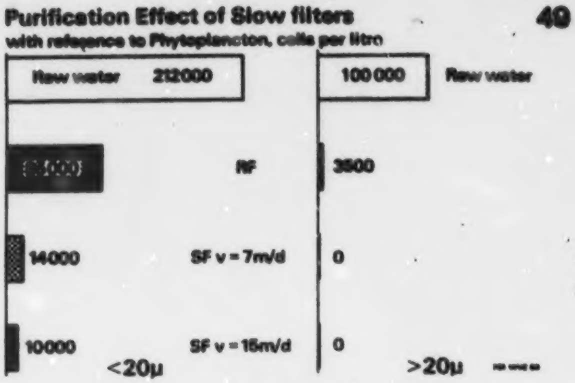
47



48


Regermination of GAC-filter

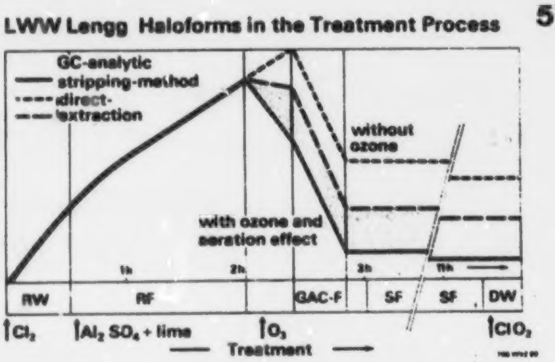
49


Purification Effect of Slow filters
with refeqence to Phytoplancton, cells per litro

50

Cl O_2 installation Lengg

51


LWW Lengg Haloforms in the Treatment Process

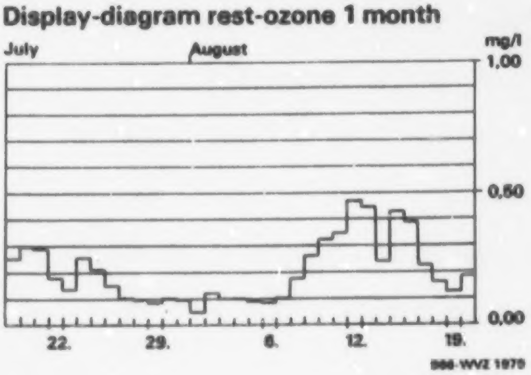
52

The effectiveness of the treatment
Right: Raw water Left: Drinking water

53

Remote control centre Hardhof

54


Display-diagram rest-ozone 1 month

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Our children too must be able to drink water !

DR. JACK DEMARCO

CINCINNATI WATER WORKS
CINCINNATI, OHIO

ORGANIC REMOVAL BY GRANULAR ACTIVATED CARBON AT CINCINNATI

ORGANIC REMOVAL BY GRANULAR ACTIVATED CARBON AT CINCINNATI, OHIO

Jack DeMarco and Richard Miller
Cincinnati Water Works
Cincinnati, Ohio

INTRODUCTION

Cincinnati's concern over the quality of the industrial Ohio River source water spans many decades. In the early 1900's, rapid sand filtration and chlorination were installed as effective methods for controlling the typhoid problems of that time. Cincinnati, Ohio and Louisville, Kentucky were leaders in applying rapid sand filtration in the United States. The typhoid death rates per 100,000 people decreased from 59 before sand filtration was installed to 11 after installation. The subsequent addition of chlorination virtually eliminated typhoid deaths. These past quality problems were well defined in that water-related pathogenic bacteria were clearly the cause of typhoid and deaths. Also, the solutions installed clearly demonstrated an immediate decrease in the typhoid rates.

The present water quality problems are not as well defined. The plethora of organic contaminants being found in trace amounts throughout the world are now the center of attention. The detection limits of organic analytical measuring equipment have made the terminology of parts per billion (ppb or ug/L) and even parts per trillion (ppt or ng/L) more than infrequently used units of measurement. The surveys already conducted have shown there is little question that man-made organics are in the ground and surface waters of the world. However, unlike the readily definable, water-related epidemics of the past, the health significance and control of organic contamination are surrounded by controversy. The cause for concern is numerous substances, difficult to pronounce and generally foreign to most of us in the water works industry. The health significance is defined by long term problems caused by carcinogens, mutagens and teratogens. The problems are reported to occur over many years rather than shortly after ingestion; therefore, the health effects are not dramatically evident. Debate continues over which ones are harmful and at what levels, if any, are permissible in our drinking water. These are controversial topics and, obviously, are a part of the critical issues that must be resolved. However, it is doubtful that undisputed answers to the many complex issues will be agreed upon soon.

Hopefully, a consensus exists within the water works industry that we'd rather not have some of these funny-sounding synthetic organic substances in our water if they can be removed economically. This is demonstrated by the fact that both utility and regulatory people have already restricted use of some water sources contaminated by synthetic organics. Data show which organics are present in water supplies, what concentrations exist, what methods can reduce contamination and what the costs will be. Basically, the solutions for organic contamination being studied include prevention, blending, aeration, oxidation and adsorption.

Obviously, prevention of contamination must be at the top of the list for use whenever possible. As mentioned, the increased use of analytic techniques have greatly aided in the detection of organic contaminants in both surface and ground water supplies. Use of these tools has already reduced the chances of intentional or accidental activities that lead to contamination. Thus, some form of testing for synthetic organics is in the best interest of our water consumers. Also, successful court actions that are taking place more frequently should foster better housekeeping by industry. However, the complete elimination of synthetic organics from our water sources appears to be unlikely in the near future.

Blending contaminated water with better quality water cannot be overlooked as a practical, short-term solution during emergency conditions. Ground water systems can generally use blending techniques more easily and more effectively than surface water systems. The duration and nature of source contamination are factors in the use of blending for emergencies.

Aeration or air stripping of organics from water has received renewed interest as an effective technique for improving water quality. Packed column, air stripping towers appear to be an economic method of transferring volatile organics in water to an air stream. The relative success follows the concepts of Henry's Law. Methods of trapping the volatile airborne contaminants might be required to prevent their escape into the atmosphere. This method is obviously not effective for high molecular weight substances.

Oxidation has not really been proven to be an effective method for changing synthetic organics into compounds that are innocuous. Oxidants, such as ozone and chlorine dioxide, have begun to gain attention as alternate disinfectants for free chlorine because of the lack of or reduction in chlorinated by-products associated with their use.

Adsorption, with powdered or granular activated carbon, has been used for organics removal at water treatment plants for a number of years. Taste and odors have been the major reasons for using activated carbon. In the mid-1970's, Cincinnati became aware of contaminants from spills and the presence of ubiquitous organics that were considered hazardous. A study by the Environmental Defense Fund listed Cincinnati among those industrial river sources reported to contain carcinogenic substances. The United States Environmental Protection Agency (USEPA) and Cincinnati Water Works (CWW) embarked on a joint project to evaluate granular activated carbon (GAC) because of the broad-based organic removal potential of carbon. The primary objectives of the project were to answer the following three basic questions:

1. How effective is GAC for removing trace organic pollutants?
2. What mode of operation for GAC is the most cost effective?
3. How much will it cost to build and operate a full-scale system?

FACILITIES DESCRIPTION

The study was conducted at the California plant of the CWW in Cincinnati, Ohio. The normal water treatment process at the 10.3 cu m/sec (235 MGD) California plant consists of primary settling, off-stream storage reservoirs, secondary settling, sand filtration and disinfection (Figure 1). The CWW system results in delivery of low turbidity water to the sand filters. Also, the storage provided by the two reservoirs is very useful during known spill conditions that frequently occur on river systems. Facilities are available to apply chlorine, aluminum sulfate and polymer to the raw water. Powdered activated carbon can also be added after primary settling, before water is delivered to the reservoirs. The plant also has facilities for feeding chlorine, ferric sulfate, lime, soda ash and powdered activated carbon between the reservoirs and secondary settling basins. Also, chlorine can be added between the secondary settling basins and sand filters as well as between the sand filters and clearwells.

Figure 2 is a schematic of the carbon units investigated at CWW. Two seperate 0.22 cu m/sec (5 MGD) sand filters were converted to sand replacement carbon systems (carbon filters). This conversion was effected by removing the 0.76 meters (30 inches) of filter sand and replacing it with 0.76 meters (30 inches) of 12 x 40 mesh carbon. A 0.175 cu m/sec (4 MGD) carbon contactor system (post-filtration adsorption system) that treats sand filtered water was also constructed. These two operating modes of carbon application provided a means of comparing the operation of a sand replacement carbon system with that of a post-filtration carbon contactor system. Table 1 lists some of the pertinent physical data that describe the carbon systems operated. Each of the four 0.04 cu m/sec (1 MGD) carbon contactors has sample ports to allow comparison with the sand replacement system at the same empty bed contact times (EBCT). Pilot carbon columns were operated parallel to the full-scale systems to assess their ability to simulate the large systems.

Figure 3 is a schematic diagram of the 227 kg/hour (500 lb/hour) fluid bed carbon reactivation system used on-site. To date, about 640 metric tons (700 tons) of carbon have been reactivated at the utility. Carbon is moved from the carbon adsorption system to a 29 cubic meter (1050 cubic foot) spent carbon storage tank. Carbon is transported from the contactors to the spent tank by hydraulically pressurizing the units to provide the motive force. Carbon is transported from the sand replacement systems by a manually fed eductor system. The carbon is dewatered to about 50% moisture and fed to the fluid bed reactivation furnace. The carbon is reactivated to near-virgin properties under a controlled combustion process, cooled by water-quenching, then placed in a 29 cubic meter regenerated carbon storage tank for subsequent transfer to the appropriate carbon adsorption system. Figure 4 is a schematic of the furnace system showing the flow process and air test sample locations.

PROJECT RESULTS

The list of trace organic contaminants that have been identified in the Ohio River and our treated water continues to expand. We have collected monitoring data that identifies over 200 specific organics. Our monitoring data identified an average of about 106 substances from the conduct of monthly closed loop stripping analyses (CLSA). USEPA has also reported over 400 specific organics during a one-time survey. These study results show there is a wide variety of substances present in low concentrations.

Table 2 lists ten of the most frequently detected organic substances. This list shows the number of detections found in the monitoring program we started in 1978 in conjunction with USEPA. The number of detections show that there are more than just an occasional occurrence of these compounds. Table 3 provides some perspective regarding the concentrations and the percent frequency of these substances in our water. The average concentration of each substance is closer to the detection limits minimum than to the maximum concentrations shown. The data indicate that high concentrations are not generally detected, but that some substances are ubiquitous at low concentrations. These data trends are likely representative of many United States industrial river sources such as the Kanawa, Ohio and Mississippi. Unfortunately, most of these substances are not well removed from the treatment process without adsorption or aeration techniques.

In the subsequent discussion of data, "without GAC" terminology refers to our normal finished water which is sand filtered and "GAC effluent" refers to our sand filtered water that was subsequently directed through GAC units.

Specific Organic Compounds

Table 4 lists 25 of the approximately 225 compounds found by using the CLSA method as described by Coleman, et al. The compounds listed were generally present in the low ng/L concentration range except for the four commonly found THMs. Of the other substances, benzene was found to have the highest influent concentration with a range of 10 to 834 ng/L. Toluene, with a concentration range of 7 to 231 ng/L, and 1,2,4-trimethylbenzene, with a range of 2 to 127 ng/L, were the only others listed on Table 4 that exceeded 100 ng/L. Most of the other substances listed are present in the concentration range of from 1 to 70 ng/L.

Over the first four months (October - February 1980) of this study, many compounds continued to be removed at a high efficiency regardless of influent concentration: 1,1,1-trichloroethane (87-100%), benzene (100%), trichloroethane and tetrachloroethane (98-100%), carbon tetrachloride (93-100%), hexachloroethane (98-100%), and chlorobenzene (100%).

The alkyl benzenes varied in percent removal with concentration. For example, toluene and 1,2-dimethylbenzene were poorly removed at about 20 to 60% when influent concentrations were at about 10 ng/L. These substances as well as others showed an increase to 99% removal when the influent concentrations increased greatly. Observations such as these should serve as a warning to carefully evaluate influent levels before making general conclusions about removal data.

Some n-aldehydes such as octanal, nonanal and decanal were normally found to be present in higher concentrations in the effluent from the GAC contactor. Recent monitoring data using purge and trap methods with a flame ionization detector and hall detector have shown that some of these compounds were present in concentrations up to 50 ug/L.

Trihalomethanes (THMS)

The GAC systems evaluated at Cincinnati were not specifically installed for THM removal. However, our data shows that the GAC effluent THM quality was considerably better than we normally produce. Figure 5 shows that for 140 days the water quality leaving the plant with carbon treatment was better than without carbon treatment. For at least two months, the GAC produced very high removal, and then the GAC effluent quality began to approach the quality of our sand filtered water that received no GAC treatment.

Figure 6 shows the results of the simulated distribution system THM measurements for two sampling points in the CWW investigation. The influent simulated distribution system THM concentrations to the carbon contactor without GAC represent the THM concentration for normal CWW sand filtered effluent samples that were stored three days in contact with free chlorine and exposed to ambient distribution temperature and pH conditions as simulated in the bottle storage procedures. The "without GAC" line, from day 14 on, indicates that the simulation process predicts that a consumer of finished water 3 days from the conventional treatment plant would receive a minimum THM concentration of 39 ug/L, a maximum THM concentration of 86 ug/L and an average THM concentration of 61 ug/L.

Although not plotted, the tap water THM concentration at an actual distribution system sampling point three days water travel time from the plant was a minimum of 34 ug/L, a maximum of 100 ug/L and an average of 61 ug/L during the same time period. Repeated results such as these at Cincinnati, along with Wood and DeMarco's reported results in similar investigations at Miami, Florida, have provided a growing confidence in the ability of this simulation procedure to predict actual distribution system concentrations. An important application of this procedure is found in evaluating the remaining data shown by the GAC effluent line in Figure 6. Once the simulation procedure is accepted, the evaluation of the predicted water quality that a consumer would receive if the water was subjected to carbon treatment and then chlorinated and transported three days under ambient pH and temperature conditions can be compared to conventional treatment. For research, this acceptance is important because the entire plant flow rarely passes through the system being tested, rendering actual distribution system sampling impractical for assessing unit process performance. The plots of Figure 6 are a comparison of what the consumer might expect with conventional treatment (without GAC line) as compared to carbon treatment (GAC line).

During the period studied, the use of GAC could be estimated to provide about 20 ug/L of TTHM in the consumers' water as contrasted to 67 ug/L provided if GAC is not used. Although the simulated distribution system THM concentrations are obviously reduced by GAC, associated costs with the inability to maintain high simulated distribution system THM removals for longer than a few months has placed limits on GAC use for maintaining low tap water THM concentrations in systems using free chlorine residuals. However, there is no doubt that GAC treatment substantially improves water quality. Even at the 10 week plateau, there exists about a 50% THM reduction because of precursor removal.

GC/FID Profiles

Figures 7-10 demonstrate the use of GC/FID capillary column profiles to provide impressions of the overall ability of GAC to remove the spectrum of organics represented by this analytic method. The following interpretations of Figures 7-10 are considered to be useful indicators of the GAC performance.

Figure 7 presents the impression that the effluent of the GAC contactor at start-up has fewer compounds, and those detected appear to have lower concentrations as seen by a lesser number of peaks and also lesser peak heights for peaks at the same retention time. Figure 7 also shows the general appearance of better GAC removal of organics after the first third of the chromatogram. The substances in the first third apparently have a lesser affinity for adsorption on carbon, less solubility in water or both.

Figure 8, third month of operation, provides the appearance of more substances present in the influent than were present in the influent shown in Figure 7; however, even with the increased appearance of more substances in the influent, the GAC effluent still appears to be of better quality than the influent.

Figure 9 shows an improvement in influent quality during the sixth month of GAC operation compared with the third month, Figure 8. The occurrence of at least two peaks in larger concentrations in the effluent than in the influent possibly indicates a desorption of these substances because of the decrease in the influent concentration.

Figure 10 shows the continued improvement of quality of the influent water to the GAC contactor. A greater number of substances also appear to have increased peak heights in the GAC effluent as compared to the GAC influent. The substances that appear to show a variable GAC performance for removal are still those that elute early on the chromatogram. The impression of desorption of previously adsorbed substances does pose a question about reactivation frequency for the GAC system. One must keep in mind, however, that the chromatograms represent impressions of relative influent/effluent concentration of detected substances and not an absolute indicator of water quality. While they serve to indicate effectiveness of treatment of the incoming water, they cannot alone indicate the requirement for the observed degree of treatment.

Organic Halogens

Few organic halogen data have been reported to date. The data in Table 5 show that during the first 4-1/2 months about 50% of the organohalide compounds designated by the OX measurement were removed. Note, although the the trihalomethane substances comprise a portion of the organic halogen concentration, the THMs do not generally account for even as much as one-third of the OX measured in this study; the reported concentrations are not corrected for THM contribution to the total. The GAC effluent OX concentration exceeded the sand filter effluent concentration at the seventh and eighth month. When the GAC influent (sand filter effluent) concentration increased rapidly at the ninth month, removal was again achieved. Contactor D was started three months after Contactor A and generally received a higher concentration of OX earlier in its life cycle. The data show that organic halogens are reduced in concentration by GAC, but that variation in effectiveness exists because of the changing GAC influent conditions.

Achieving a specific GAC effluent concentration level would provide different carbon life cycles for the two contactors. For example, if the GAC effluent OX concentration was to be maintained at less than 40 ug/L, Table 3 data would indicate that one GAC contactor could be used for about seven months, whereas the other GAC contactor would have a useful life of about five months.

Thus, the variation of influent concentrations and possibly chemical characteristics of OX materials to identical contactors was seen to cause significant change in expected adsorber life for a given target effluent. Therefore, careful definition of breakthrough curves under one set of conditions does not necessarily define the performance of even identical adsorber systems with the present state of understanding of the meaning of this parameter and its natural controlling factors.

Total Organic Carbon

Figure 11 is a detailed plot of the TOC data. The generation of such plots allows the evaluation of the ability of the GAC system to remove a variety of nonspecific organic substances present in most drinking water. The 0.2 mg/L concentration of TOC that is present in the initial effluent of the 4.6 meters (15 feet) deep carbon bed (15 minute EBCT) is probably caused by the presence of a fraction of the TOC that is not carbon adsorbable under the conditions tested. Results of studies of various long carbon contact time systems at other locations have shown similar patterns. Although the TOC measurement does not measure specific organic compounds, it does serve to document some advantages and disadvantages of GAC. Note that the carbon achieves 90% removal for about six weeks before the rapid breakthrough of TOC takes place and a steady state plateau is established below the influent concentration, (about 40% removal). These results (steady state plateau) have supported speculation that biodegradation may also provide a useful asset in drinking water systems either with or without carbon.

GAC Cost Estimates

Various cost estimates have been made based on the data collected during our GAC testing program. Table 6 shows some of the unit costs used. The actual conduct of the study utilized a 4 MGD post-filtration GAC system and a 10 MGD sand replacement GAC system. Thus, actual data exists for these two systems. Projections were made for full scale operation to show estimated costs on the basis of a 200 MGD design rate for each type system. Table 7 is a full-scale estimate contained in our final research project report. Although similar total capital costs were projected, annual operating costs were considered to be higher for the filter system because of less efficient GAC utilization.

The total annual operating and maintenance cost between the two systems were estimated to differ by about four million dollars because of greater make-up carbon requirements for the filter system. Higher carbon losses were found in the sand replacement system reactivation process during the project. The added estimated cost for full-scale filter operation was 24¢/1000 gallons (6.3¢/M^3) compared to 16.5¢/1000 gallons (4.3¢/M^3) for post-filtration contactor operation.

PROGRESS TOWARD FULL-SCALE DESIGN

Based on the study results, the City of Cincinnati Council passed a resolution approving two million dollars for a detailed engineering design of a full-scale GAC system. A water rate increase was passed to finance the study. A conceptual design competition resulted in three excellent groups with different concepts on what was the most appropriate GAC system for the California plant. Figure 12 shows the schematic of our plant with the selected GAC system for implementation. Primarily, a post GAC filtration facility and pump station were added to our regular process stream as shown on Figure 12. We anticipate that chemicals will be delivered as follows:

1. Alum and/or cationic polymer at Lamella influent for settling of raw water turbidity and solids;
2. PAC or algicide for algae control at reservoirs;
3. Ferric sulfate as needed for colloidal turbidity removal before secondary settling, at the east chemical building;
4. Fluorides for tooth decay prevention at the east chemical building;
5. Zinc orthophosphates for stability and free chlorine disinfection after GAC contactors.

Primary features of alternative designs that were carefully considered included an upflow GAC system prior to sand filtration in one design and conversion to high rate filtration, elimination of secondary settling basins and post filtration gravity GAC filtration in another. All proposals were well conceived and, obviously, the one that was judged to be most appropriate was selected for final design

Our timetable estimates that bid advertisement may occur early in 1985 if all approvals are received. The final design memo that starts full-scale design is being developed at this time; however, we expect that the design features will include the following:

- Post filtration GAC adsorption with downward flow	
- Provision for removing upper portion of or entire GAC bed	
- Empty Bed Contact Time	
At 175 MGD (Design Flow)	15.0 minutes
At 124 MGD (Annual Average Flow)	21.2 minutes
- Surface Loading Rate	
At 175 MGD (Design Flow)	5.5 gpm/ft^2
At 124 MGD (Annual Average Flow)	3.9 gpm/ft^2
- Number of Contactors (including 1 spare)	12
- Surface Area per Contactor	1,950 sq. ft.
- GAC Volume per Contactor	22,182 cu. ft.
- GAC Depth	11.4 ft.
- Total GAC Volume (11 Contactors)	244,000 cu. ft.
- Total Maximum Reactivation Capacity (2 Fluid Beds)	100,000 lb. GAC/day
- Annual Carbon Use Rate	50,000 lb. GAC/day
- Peak Carbon Use Rate	90,000 lb. GAC/day

Part of the rationale that we used in selecting the system being designed was based on our belief that the first system of its kind must contain little or no risks. At the same time, economics were a vital part of our criteria. We believe that, based on the data collected during our project with EPA, we have selected the best system for our industrial river location.

No matter how well we may monitor our source water, how diligently we may regulate industrial effluents, barge, rail, and highway transport, the unwanted spillage of organics will occur. The use of granular activated carbon, as planned at CWW, will provide our consumers with another barrier against pollution. Historically, our industry has implemented pollution barriers such as settling and sand filtration. Perhaps granular activated carbon systems like ours will find widespread acceptance at large utilities as practical solutions for organic contamination. Regardless, the technology is proper for our situation. We look forward to the opportunity for improving the water quality delivered to our consumers at a reasonable cost.

Acknowledgements

We wish to express our appreciation to the Division of Water Quality and Research staff who contributed their time and effort in performing the analytical tests, to Engineering and Supply Division staff for their assistance in design, assembly and operation of equipment, to the Engineering Division for timely assistance in graphic preparations and to Deborah Metz, David Hartman and Cherie Chessey in the preparation of this manuscript.

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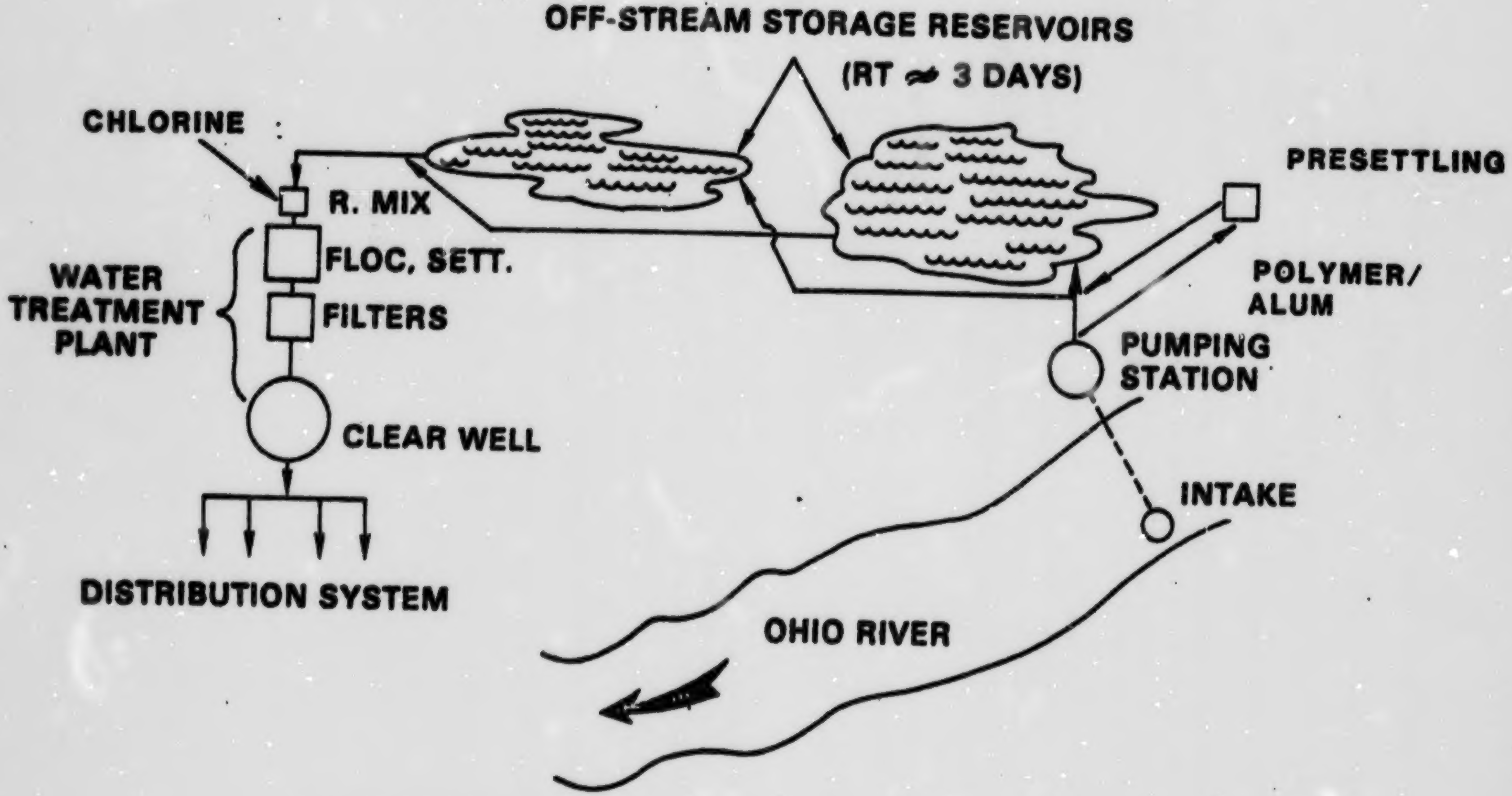
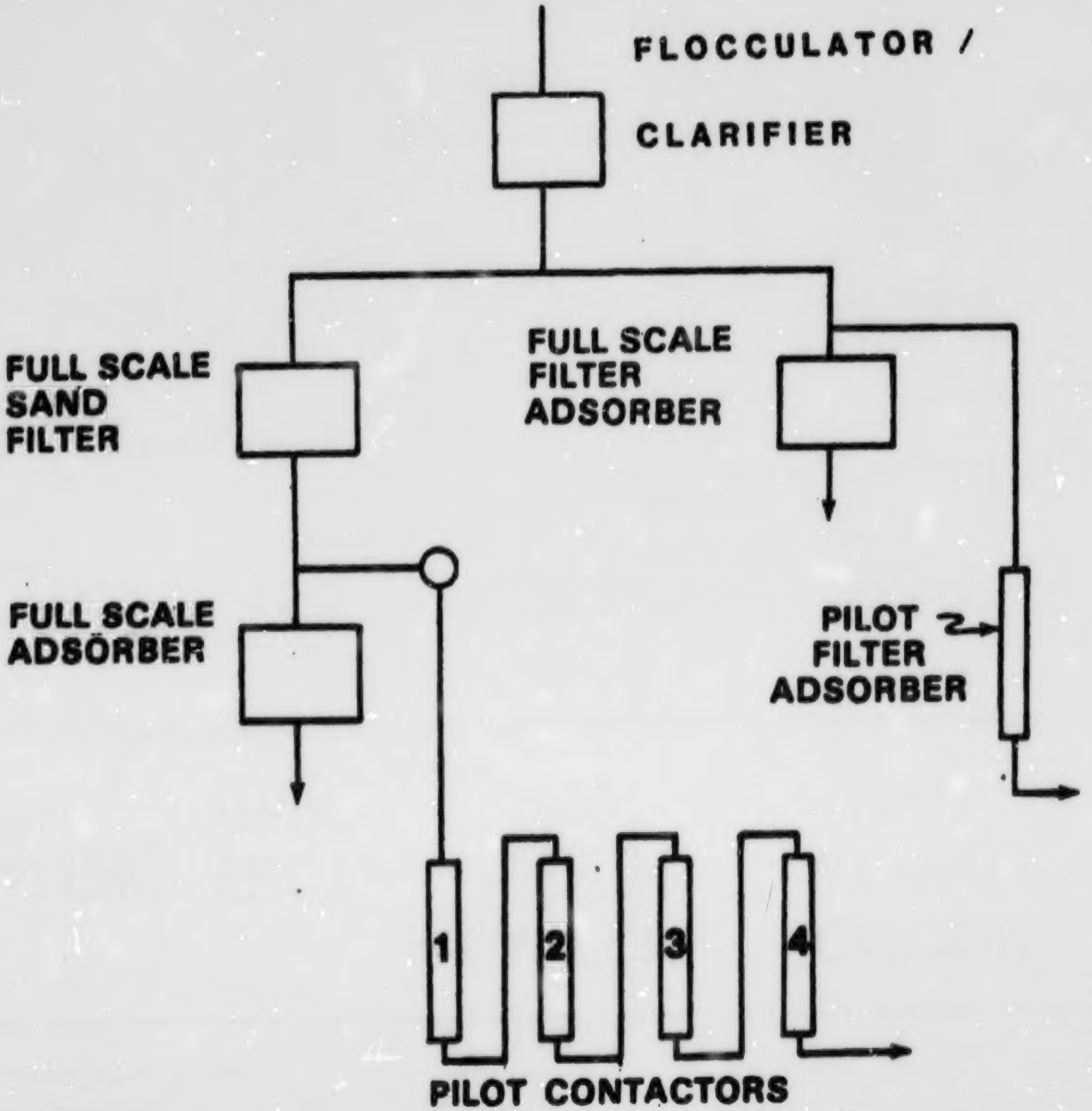


OFF-STREAM STORAGE RESERVOIRS
(RT ≈ 3 DAYS)
CHLORINE
R. MIX
FLOC. SETT.
FILTERS
WATER TREATMENT PLANT
CLEAR WELL
DISTRIBUTION SYSTEM
PRESETTLING
POLYMER/ ALUM
PUMPING STATION
INTAKE
OHIO RIVER

SCHEMATIC OF CINCINNATI WATERWORKS

FIGURE 1


FLOCCULATOR /
CLARIFIER
FULL SCALE SAND FILTER
FULL SCALE FILTER ADSORBER
FULL SCALE ADSÖRBER
PILOT FILTER ADSORBER
1
2
3
4
PILOT CONTACTORS

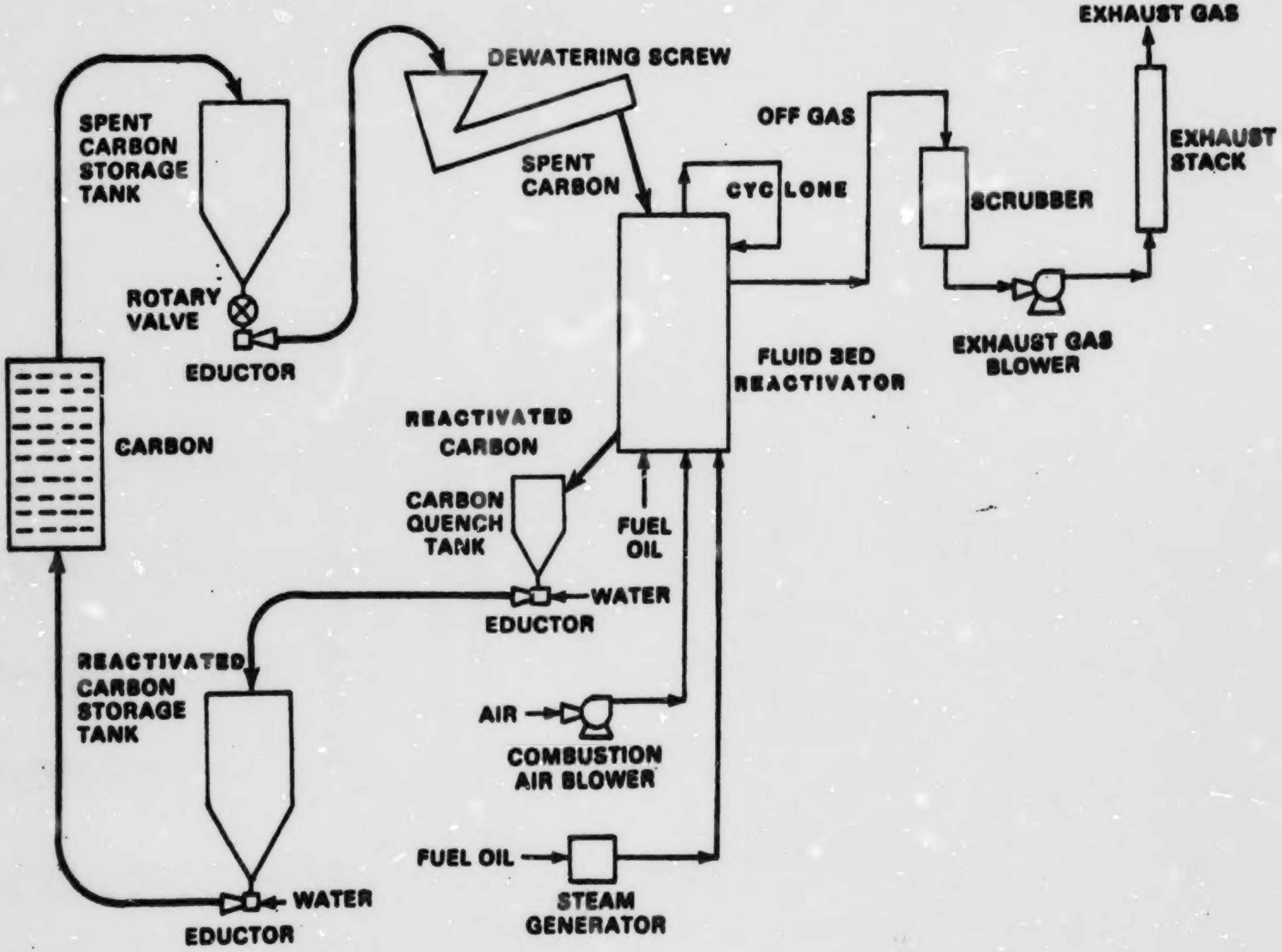
SCHEMATIC OF CARBON UNITS

FIGURE 2

PHYSICAL DATA FOR CARBON SYSTEMS

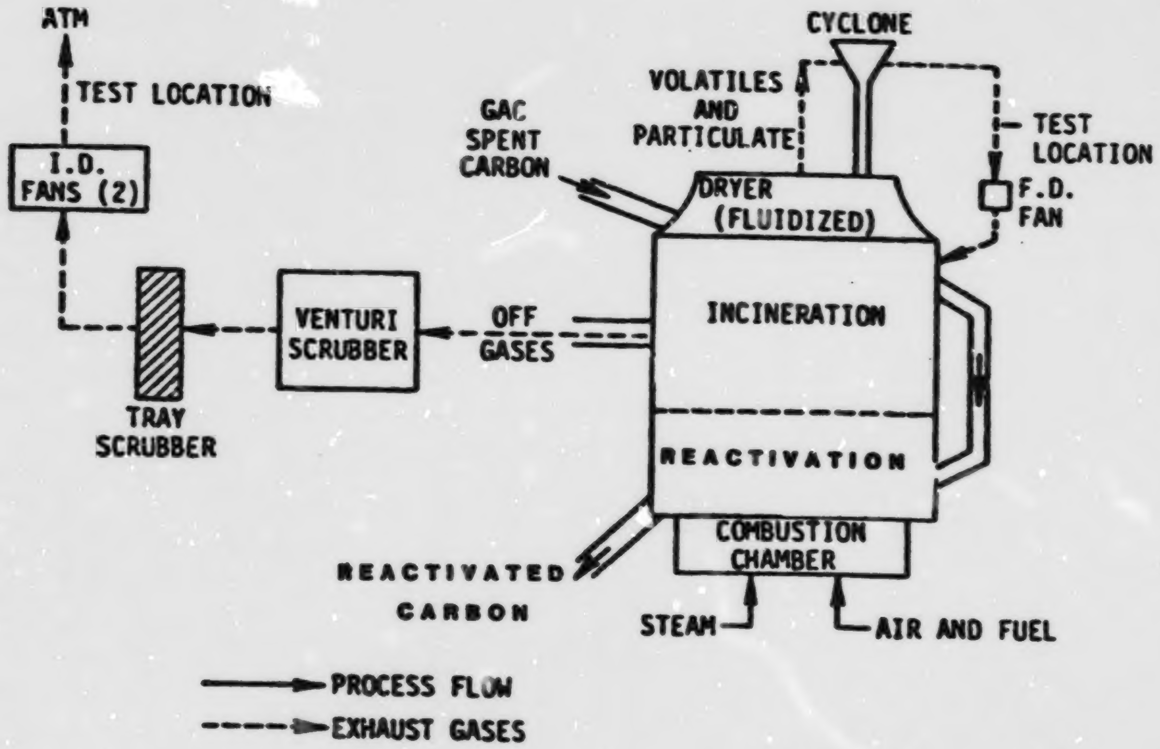
CARBON SYSTEM	FLOW	EBCT (min)	CARBON DEPTH (ft)	CARBON WEIGHT (lbs)	HYDRAULIC LOADING (gpm/sq ft)
Post Filtration Contactor	1MGD	15.3	15.0	43,600	7.4
Sand Replacement	5MGD	7.5	2.5	103,000	2.5

TABLE 1


EXHAUST GAS
DEWATERING SCREW
SPENT CARBON STORAGE TANK
OFF GAS
EXHAUST STACK
SPENT CARBON
CYC LONE
SCRUBBER
ROTARY VALVE
EDUCTOR
FLUID BED REACTIVATOR
EXHAUST GAS BLOWER
CARBON
REACTIVATED CARBON
CARBON QUENCH TANK
FUEL OIL
WATER
EDUCTOR
REACTIVATED CARBON STORAGE TANK
AIR
COMBUSTION AIR BLOWER
FUEL OIL
STEAM GENERATOR
WATER
EDUCTOR

CARBON TRANSPORT AND REACTIVATION SYSTEM

FIGURE 3


ATM
TEST LOCATION
I.D. FANS (2)
TRAY SCRUBBER
VENTURI SCRUBBER
OFF GASES
GAC SPENT CARBON
VOLATILES AND PARTICULATE
CYCLONE
TEST LOCATION
F.D. FAN
DRYER (FLUIDIZED)
INCINERATION
REACTIVATION
COMBUSTION CHAMBER
REACTIVATED CARBON
STEAM
AIR AND FUEL
PROCESS FLOW
EXHAUST GASES

FURNACE PROCESS FLOW

FIGURE 4

TOP TEN RAW WATER CONTAMINANTS DETECTED

SUBSTANCE	No. SAMPLES	No. DETECTED
CHLOROFORM	866	705
BENZENE	361	217
TOLUENE	360	168
DICHLOROMETHANE	787	3[illegible]5
1,2–DICHLOROBENZENE	728	174
TETRACHLOROETHYLENE	740	124
1,1,1–TRICHLOROETHANE	760	103
ETHYLBENZENE	329	31
1,2–DICHLOROETHANE	802	58
TRICHLOROETHYLENE	808	55

As of January 1984

TABLE 2

TOP TEN RAW WATER CONTAMINANTS DETECTED
(ug/L)

SUBSTANCE	CONCENTRATION Min.	Max.	Ave.	DETECTION FREQUENCY
CHLOROFORM	ND	5.4	0.2	81
BENZENE	ND	4.5	0.2	60
TOLUENE	ND	18.6	0.2	47
DICHLOROMETHANE	ND	11.9	0.12	41
1,2–DICHLOROBENZENE	ND	1.2	0.05	24
TETRACHLOROETHYLENE	ND	0.44	0.03	14
1,1,1–TRICHLOROETHANE	ND	1.0	0.03	12
ETHYLBENZENE	ND	33.0	0.1	9
1,2–DICHLOROETHANE	ND	2.0	0.01	7
TRICHLOROETHYLENE	ND	0.2	0.01	7

As of January 1984

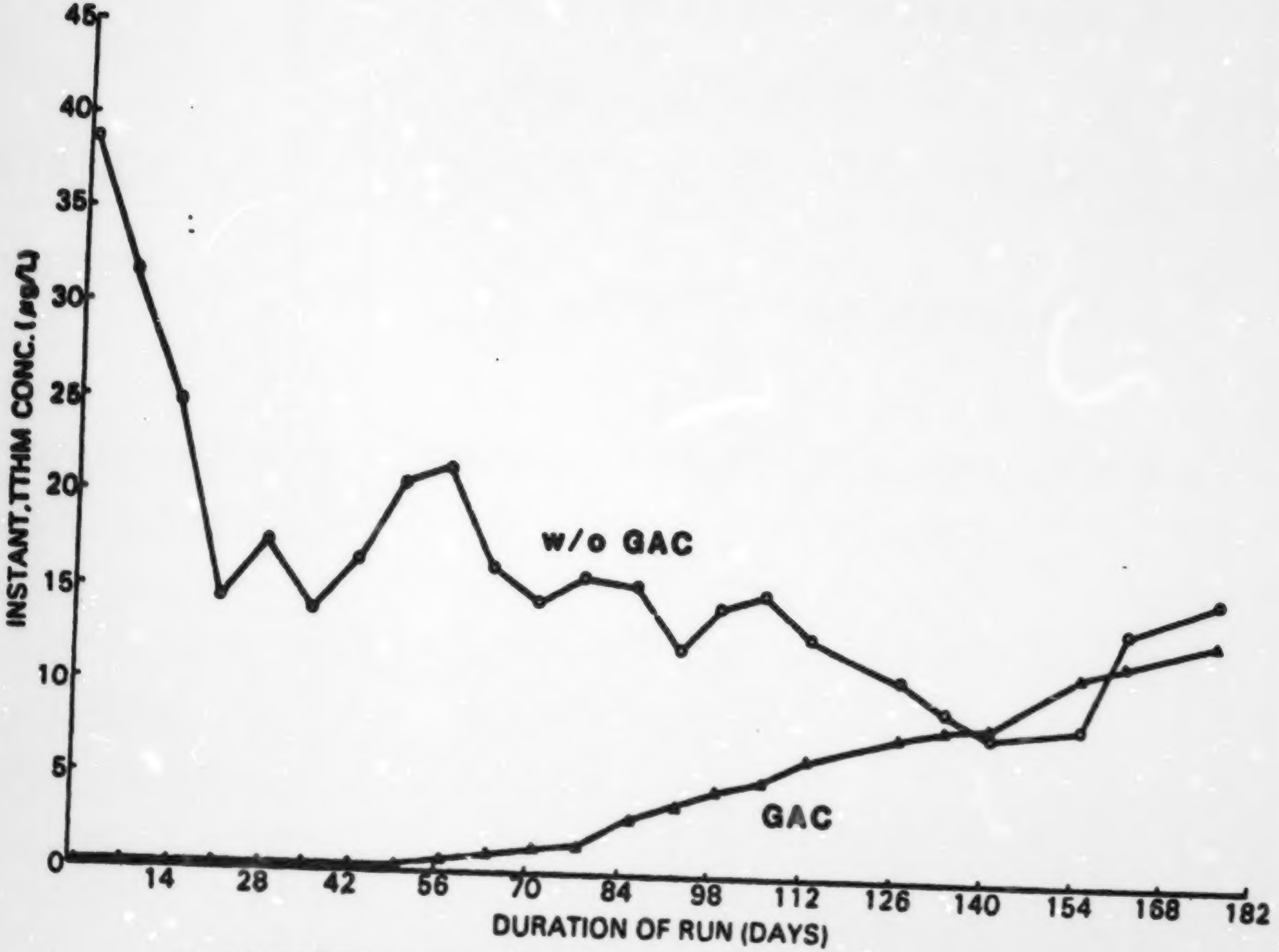
TABLE 3

EXAMPLE OF ORGANICS FOUND BY CLSA TECHNIQUE

	Percent Removal*				
Compounds	Start-up	1 Mos	2 Mos	3 Mos	4 mos
1,1,1-Trichloroethane	100	95	87	94	98
Trichloroethene	-	98	98	100	100
Tetrachloroethene	100	100	98	100	100
Benzene	-	100	-	100	100
Carbon Tetrachloride	100	94	93	100	100
Hexachloroethane	100	99	99	100	99
Chloroform	100	98	72	79	70
Bromodichloromethane	100	100	93	98	90
Dibromochloromethane	100	100	97	100	97
Dichloroiodomethane	100	100	100	100	100
Bromoform	100	100	100	100	98
1,2-Dichloropropane	-	100	-	-	-
1,2-Dichlorobenzene	100	100	99	100	99
1,2,4-Trichlorobenzene	95	96	96	100	98
Toluene	38	52	-3	59	100
1,2-Dimethylbenzene	40	58	17	59	99
Isopropylbenzene	38	50	33	67	99
Propylbenzene	33	36	0	62	97
1,2,4-Trimethylbenzene	27	43	11	46	99
1,2,3-Trimethylbenzene	33	46	20	50	99
Heptadecane	35	+	-177	100	+
Octanal	+	+	-77	39	+
Heptanal	-	+	-50	-	+
Decanal	-150	-683	-177	-17	+
Nonanal	-350	-328	-152	-9	-1271

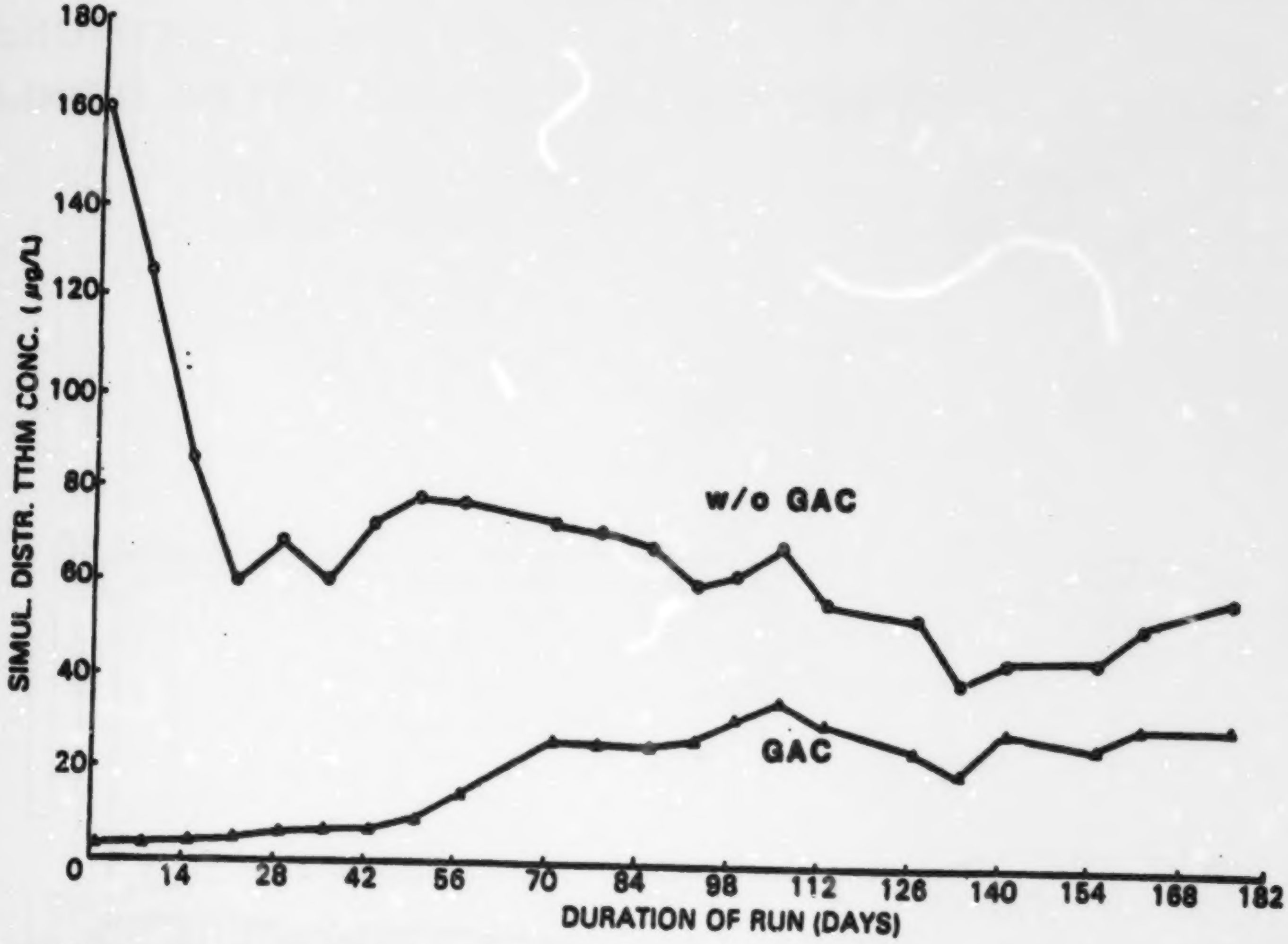
- Not detected in either influent or effluent
+ Effluent concentrations quantifiable, but influent concentrations not quantifiable.
* 100 percent removal indicates not detected in effluent.

TABLE 4



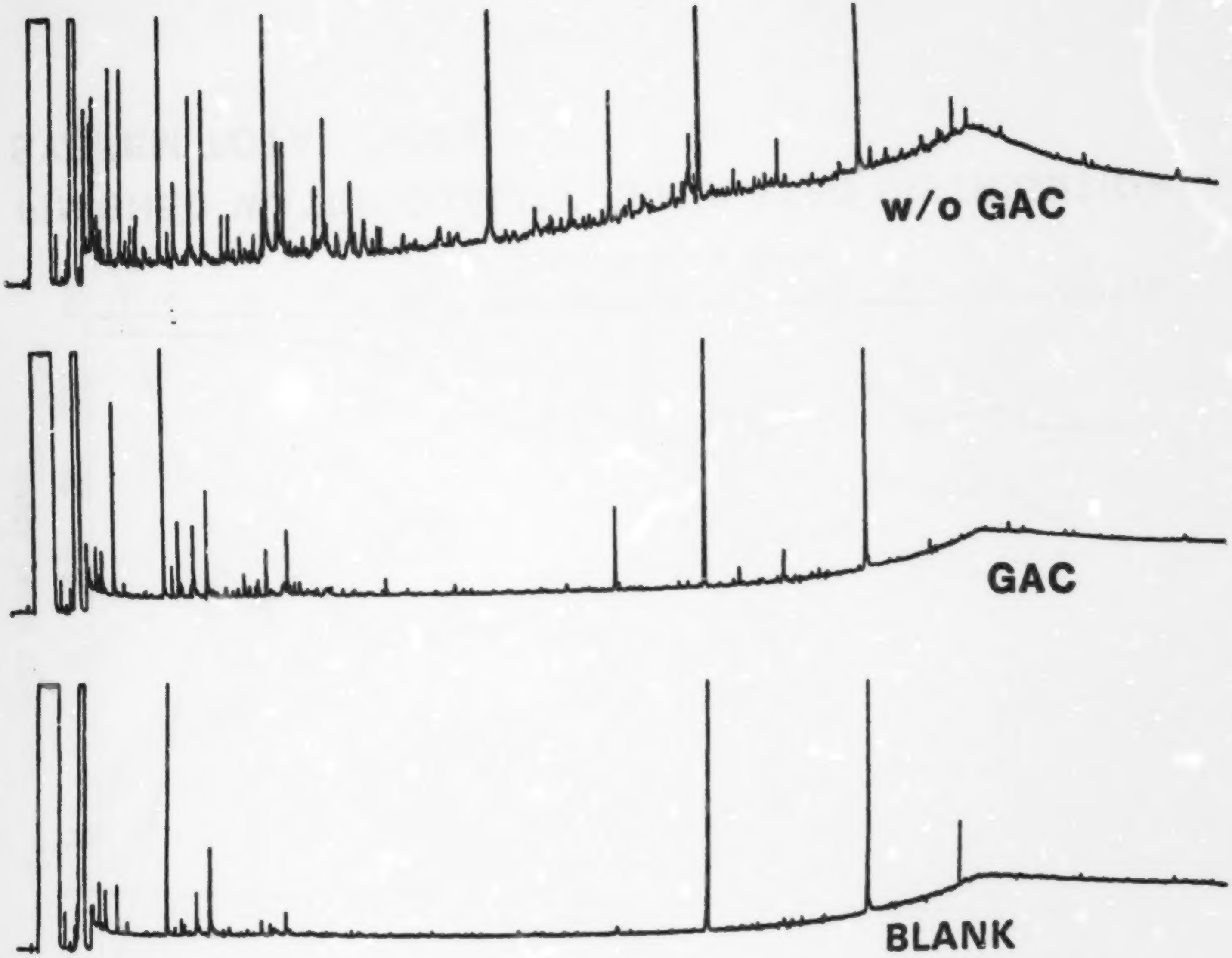
FINISHED WATER QUALITY, TOTAL THM's

FIGURE 5



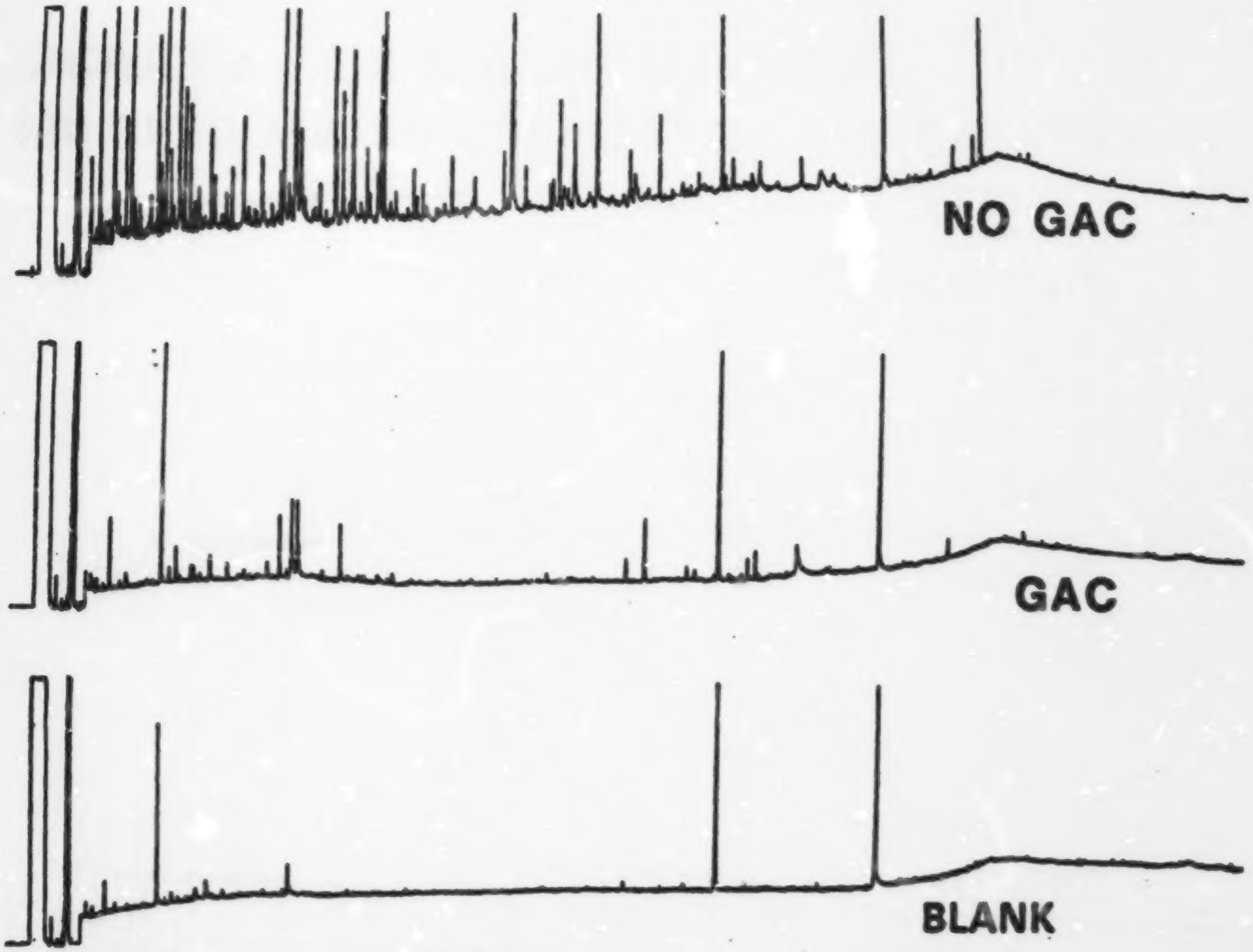
FINISHED WATER QUALITY, SIMULATED DISTRIBUTION SYSTEM TOTAL THM's

FIGURE 6



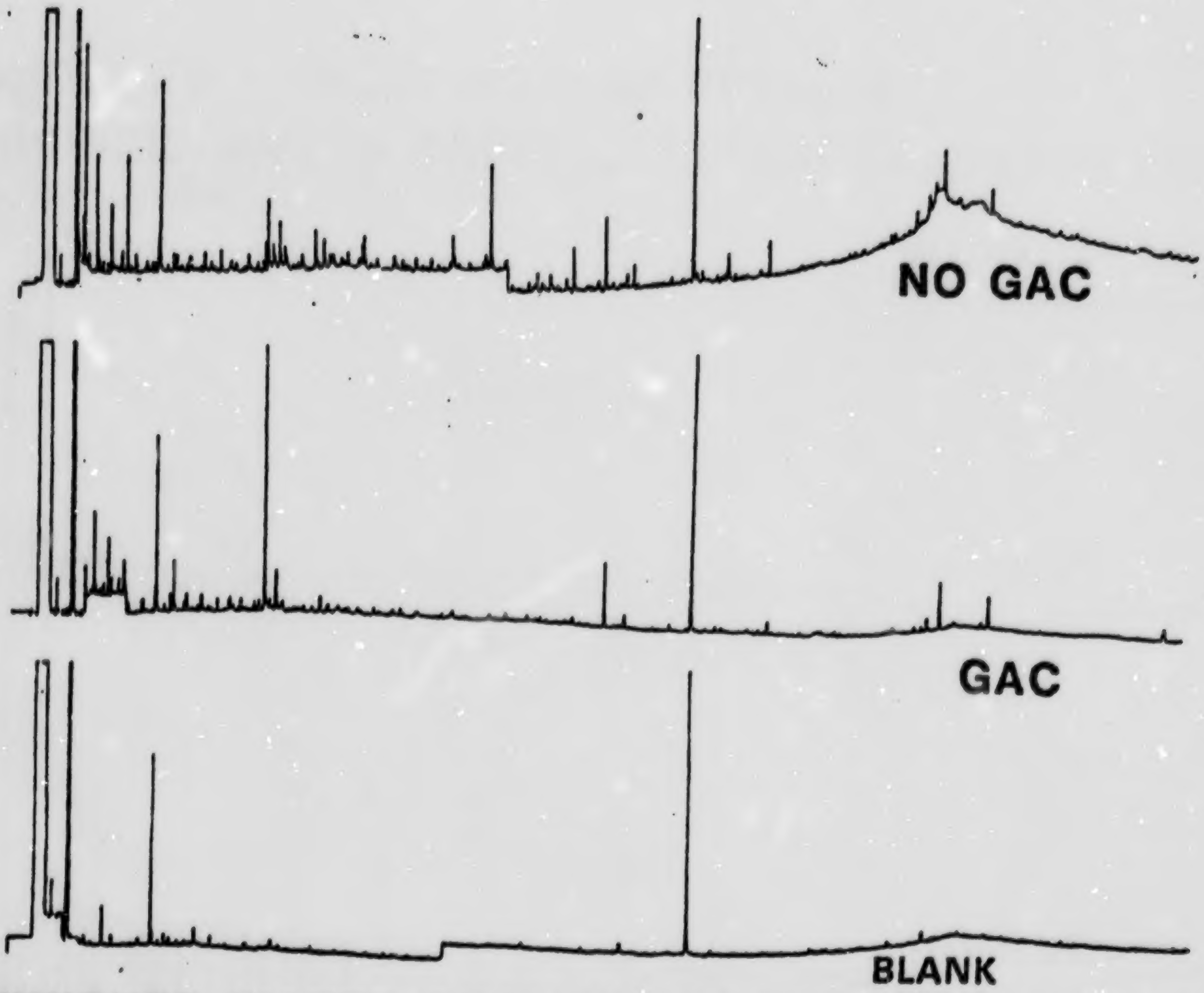
FINISH WATER QUALITY, GC/FID CAPILLARY COLUMN PROFILES - START - UP

FIGURE 7



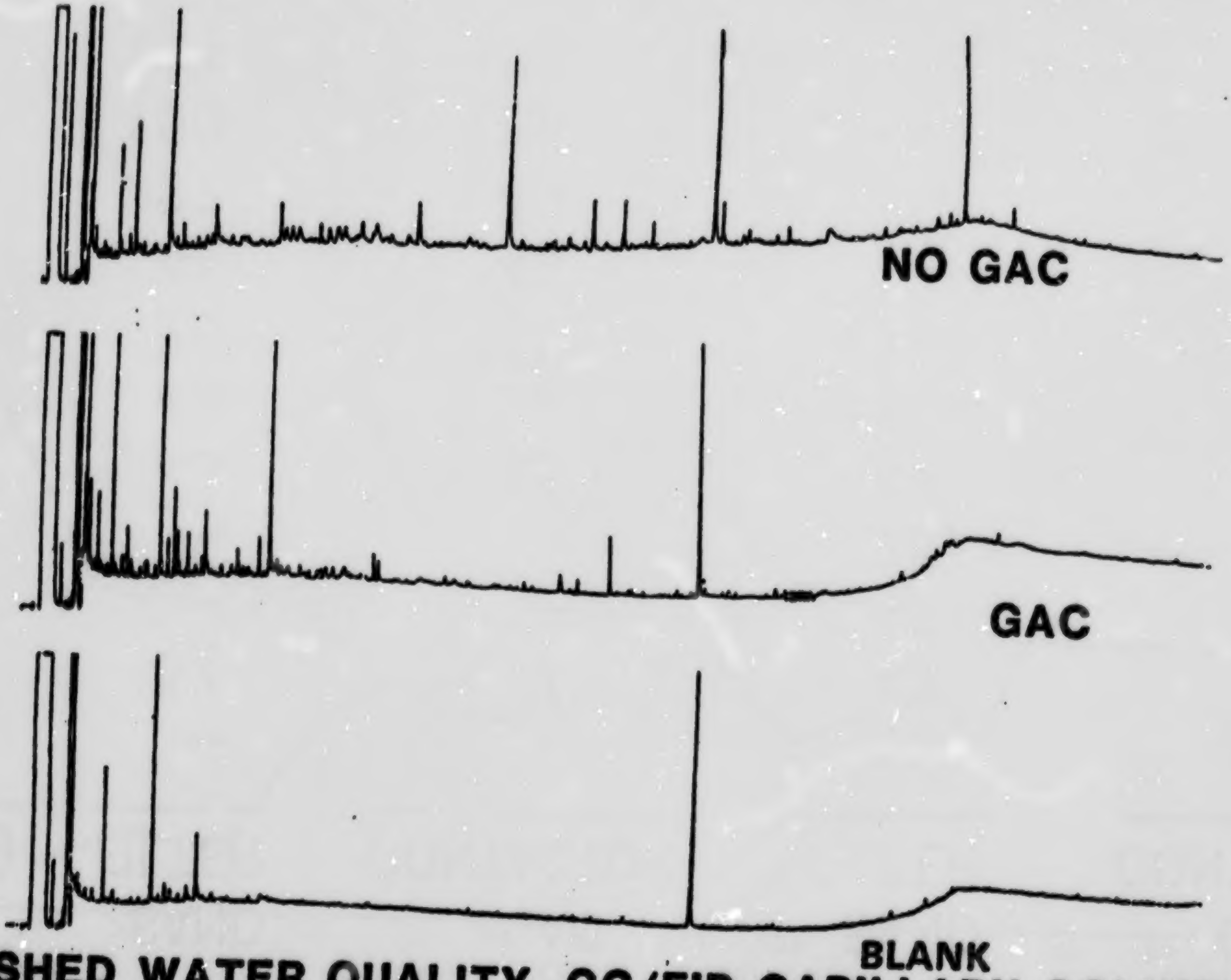
FINISHED WATER QUALITY, GC/FID CAPILLARY COLUMN PROFILES - THREE MONTHS SERVICE.

FIGURE 8



FINISHED WATER QUALITY, GC/FID CAPILLARY COLUMN PROFILES - SIX MONTHS SERVICE

FIGURE 9



FINISHED WATER QUALITY, GC/FID CAPILLARY COLUMN PROFILES - SEVEN MONTHS SERVICE.

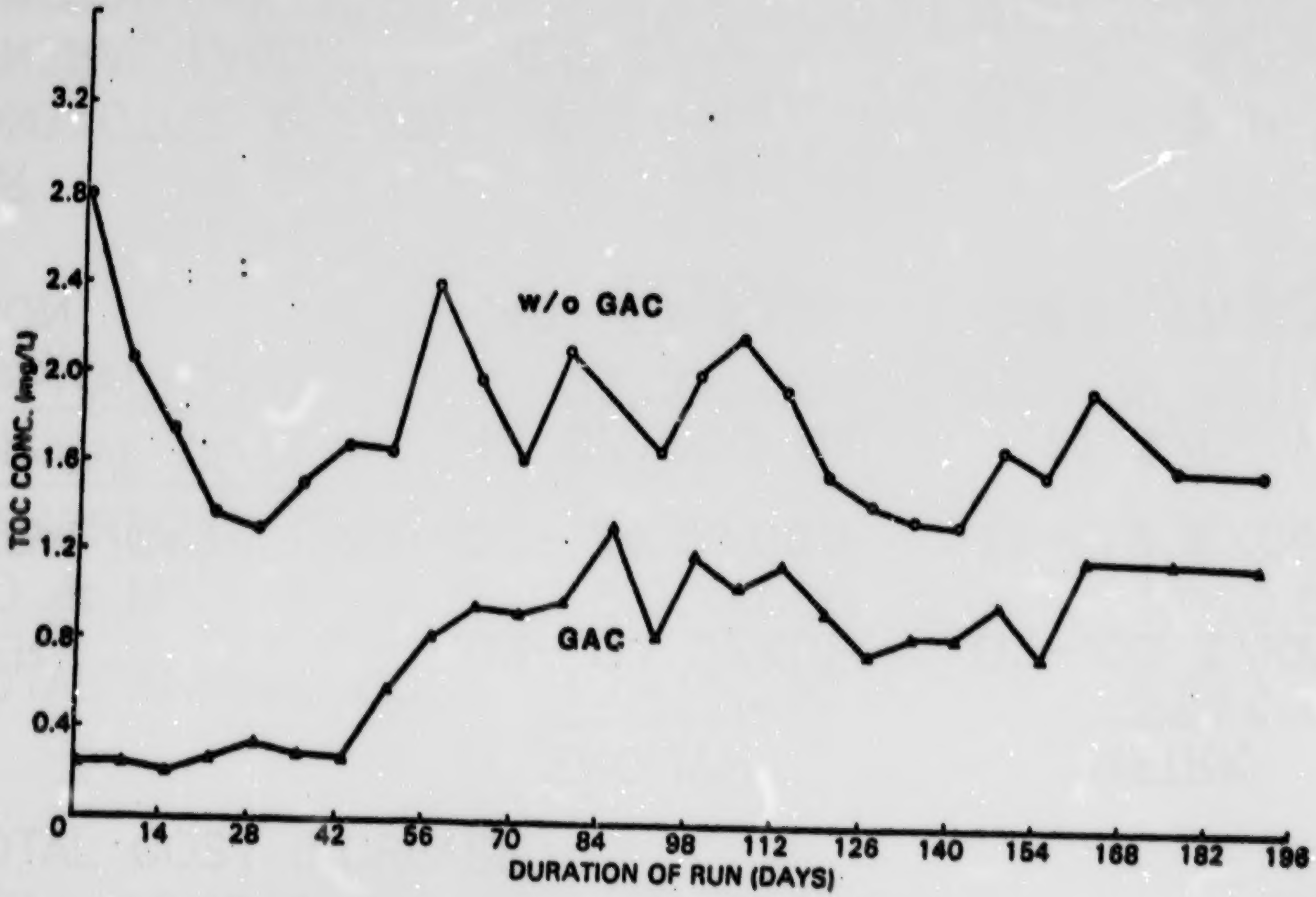
FIGURE 10

FINISHED WATER QUALITY
TOTAL ORGANIC HALOGEN, ug/L

TIME (MONTHS)	SAND FILTER	GAC CONTACTOR	SAND FILTER	GAC CONTACTOR
0	–	–	51	3
1	57	7	43	5
2	–	–	46	8
3	–	–	76	10
4.5	43	23	44	16
5.5	46	24	150	44
6.5	76	31	174	77
7	44	49	–	–
8	27	43	–	–
9	150	89	–	–
10	174	103	–	–

Total Organic Halogen as Cl^-

TABLE 5



FINISHED WATER QUALITY, TOC.

FIGURE 11

CWW UNIT COSTS

	ENGLISH	METRIC
POWER	.02–.03 $/KWH	.02–.03 $/KWH
NATURAL GAS	.31–.34 $/CCF	.11–.12 $/Cu M
WATER	.42 $/1000 Gal	.11 $/Cu M
CARBON	.49–.53 $/Lb	1.08–1.17 $/KG
LABOR		
CONTACTOR & FURN.	8 $/Hr	8 $/Hr
GENERAL LABOR	6.5 $/Hr	6.5 $/Hr
MAINTENANCE	7–9 $/Hr	7–9 $/Hr

TABLE 6

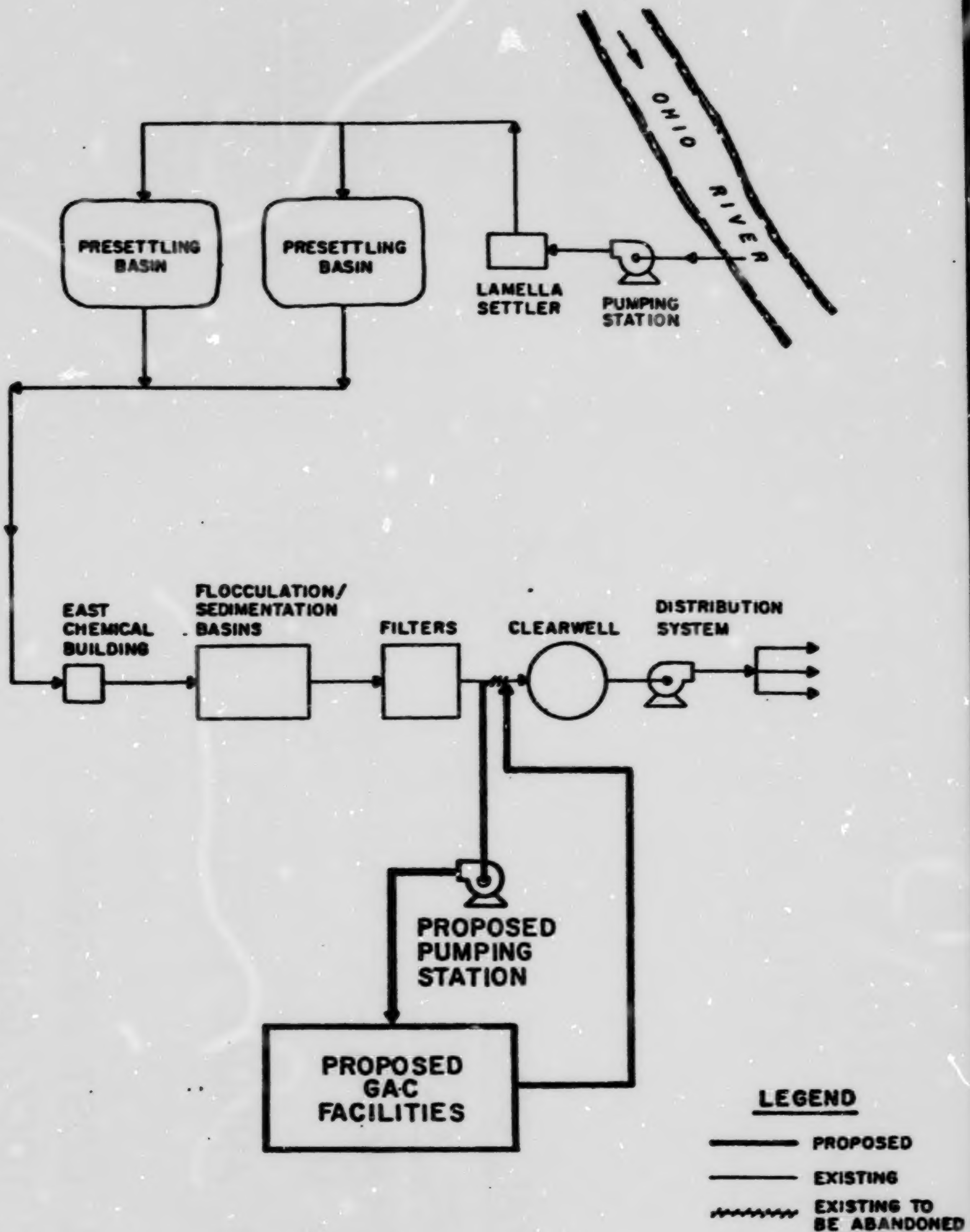
PROJECT COST ESTIMATES

FULL SCALE GAC AT CWW

(DOLLARS)

	FILTERS	CONTACTORS
CAPITAL COST	37,300,000	38,500,000
ANNUAL COST		
AMORTIZED CAPITAL	4,381,260	4,522,210
O & M	8,030,000	4,020,000
TOTAL ANNUAL COST	12,411,260	8,542,210
TOTAL COST INCREASE (Per 1000 Gallons)	0.240	0.165
TOTAL COST INCREASE (Per Cu. M)	0.063	0.043

TABLE 7


OHIO RIVER
PRESETTLING BASIN
PRESETTLING BASIN
LAMELLA SETTLER
PUMPING STATION
EAST CHEMICAL BUILDING
FLOCCULATION/ SEDIMENTATION BASINS
FILTERS
CLEARWELL
DISTRIBUTION SYSTEM
PROPOSED PUMPING STATION
PROPOSED GAC FACILITIES
LEGEND
PROPOSED
EXISTING
EXISTING TO BE ABANDONED OR MODIFIED

SCHEMATIC OF CALIFORNIA PLANT
WITH POST - FILTRATION GAC ADSORPTION

FIGURE 12

DR. RIP G. RICE

CONSULTANT
ASHTON, MARYLAND

OZONE TREATMENT OF DRINKING WATER
EVOLUTION AND CURRENT STATUS

OZONE TREATMENT OF DRINKING WATER --
EVOLUTION AND PRESENT STATUS

Rip G. Rice, Ph.D.
Rip G. Rice, Incorporated
1331 Patuxent Drive,
Ashton, Maryland 20861 (USA)

Abstract: Since its adoption by the City of Nice, France in 1906 for disinfection of drinking water, the use of ozone as a water treatment agent has grown in importance. Early installations used ozone primarily for disinfection at the end of the treatment process. In modern times, however, the use of ozone as a chemical oxidant during early stages of water treatment have become prevalent. In light of current recognition of problems of organics in drinking water, modern water treatment facilities are learning how to combine ozone as a chemical oxidant with other water treatment steps, including ozone disinfection. The overall benefit of two- or three-stage ozonation to the improved quality of water becomes one of removing detrimental organic materials to minimize the amount of chlorine compound residual required for the distribution system.

EARLY HISTORY (Hill and Rice, 1982)

Although ozone was first discovered in 1840 by Schönbein during electrolysis experiments, early studies on its use as a germicide for treating potable water were not conducted until 1886, by de Meritens in France. Early pilot plant tests of ozone disinfection at potable water plants were conducted in Oudshoorn, the Netherlands (1893), Paris, France (late 1890s), Lille, France (1898) and Paderborn and Wiesbaden, Germany (1902 and 1903, respectively).

In 1906 ozone disinfection was installed at the Bon Voyage water treatment plant in Nice, France. Because of the fact that ozone has been used to treat Nice city waters ever since, Nice has become known as the "birthplace of ozonation for potable water treatment". The Bon Voyage plant operated until 1970, during which time two additional potable water plants incorporating ozone were constructed as the city and its suburbs grew in size. In 1970 the new and completely modernized Super Rimiez plant (still incorporating ozone) was constructed on a mountaintop overlooking Nice, and the three older plants were shut down.

In 1916, Vosmaer listed a total of 49 European water treatment plants using ozone, 26 of which were located in France. As of 1977, at least 1,036 water treatment plants throughout the world were using ozone (Miller, *et al.*, 1978), and about half of these were located in France. It is noteworthy that Switzerland, a country no larger in size than the state of New Jersey, had 150 operating water treatment plants using ozonation in 1977.

During 1977, there were 23 drinking water treatment plants in Canada using ozone, all except one in the Province of Quebec. At the same time, there were only 5 plants using ozone in the United States. Today there are 40 to 50 operational plants in Canada (several outside of Quebec Province), and 17 in the USA. Another five American plants are under construction.

PROPERTIES OF OZONE PERTINENT TO WATER TREATMENT

Generation

At normal temperatures and pressures encountered in drinking water treatment plants, ozone is a gas, which is prepared on-site. This is accomplished by passing a dry, oxygen-containing gas (usually air for water treatment plants) between two electrical plates separated by a ceramic dielectric and a narrow discharge gap. Under these conditions, part of the oxygen is converted to ozone:

$$3O_2 \rightleftharpoons 2O_3$$

It is important to recognize that the synthesis reaction produces rather low yields of ozone, usually 1 to 3% when air is the feed gas, and 2 to 6% when pure oxygen is the feed gas.

It is also noteworthy that the reaction is an equilibrium one, meaning that ozone also decomposes back to oxygen from which it is formed. Heat increases the rate of the reverse reaction. Therefore, because ozone generation produces relatively large quantities of heat as a by-product, efficient cooling of the ozone generator is important to maximize ozone yields.

Contacting

Ozone is only partially soluble in water, as a rule of thumb, about 13 times the solubility of oxygen. As a result, applying ozone to water involves gas/liquid contacting. This can be accomplished in a variety of ways, which involve tradeoffs between additional energy required by the various available contacting systems, versus contact chamber size and contact time.

For detailed discussions of the generation and contacting of ozone, the reader is referred to recent treatises by Carlins and Clark (1982) and Masschelein (1982).

Oxidizability

Table I shows the relative oxidation potentials of a number of chemicals. Of those materials readily available for water treatment, ozone is the most powerful, having an oxidation potential about 1.5 times higher than that of chlorine. This means that ozone will oxidize materials faster, will attain a level of disinfection faster (or with lower concentrations), and sometimes will oxidize materials that weaker oxidants will not oxidize. More detailed discussions of ozone oxidation of organic materials will be found in later sections of this paper.

TABLE I. RELATIVE OXIDATION POWER OF OXIDIZING SPECIES

Species	Oxidation Potential, volts	Relative Oxidation Power*
fluorine	3.06	2.25
hydroxyl radical	2.80	2.05
atomic oxygen	2.42	1.78
ozone	2.07	1.52
hydrogen peroxide	1.77	1.30
perhydroxyl radicals	1.70	1.25
hypochlorous acid	1.49	1.10
chlorine	1.36	1.00

* based on chlorine as reference point (= 1.00)

Ozone Residual

In properly treated drinking water, a measureable residual of ozone can be attained readily in the treatment plant. In fact, attainment and maintainment of specific and reproducible levels of dissolved ozone residual is used as a means of controlling and automating ozone disinfection processes. However, this residual is not sufficiently stable in the distribution system to provide continuing bacteriostatic activity. Consequently, it is usual practice to follow ozone disinfection, at the end of the water treatment process, with small quantities of chlorine, chlorine dioxide, or chloramine, depending upon local conditions. More will be said on this subject in the next section.

When ozone disinfects or oxidizes, oxygen atoms are introduced into the chemical structures of the materials being oxidized. Free oxygen also is released into solution. No halogenated by-products of oxidation are produced upon ozonation. This is a significant difference between ozone, which acts as a disinfectant and chemical oxidant, versus chlorine, which also acts as a disinfectant and chemical oxidant, but also as a chlorinating agent.

Solving the current problems of halogenated organics in water supplies involves trying to minimize the unwanted chlorinating reactions while maintaining the disinfecting and/or chemical oxidation capabilities of chlorine. One of chlorine's strongest advantages in water treatment is its ability to provide a stable bacteriostatic residual in the distribution system.

APPLICATIONS OF OZONE IN WATER TREATMENT (Rice et al., 1981)

Bacterial Disinfection

WHen used for disinfection, ozonation normally is conducted at the end of the treatment process. This means that chemical addition, flocculation, sedimentation and filtration all have been accomplished prior to the water being ozonized. The efficiency of the pretreatment process(es) to remove organics and other ozone-demanding constituents will determine the amount of ozone required to attain disinfection. In turn, the amount of oxidizable organic materials remaining when ozonation is conducted will determine the amount and types of organic oxidation products which will be formed in the ozonized water.

Operational French water treatment plants treating river water by means of chemical addition, flocculation, sedimentation, and filtration prior to ozone disinfection in the suburbs of Paris, normally apply 2.0 to 4.0 mg/L of ozone for disinfection. This dosage can increase to over 6 mg/L during warm summer conditions.

Because ozone is a much stronger bactericide than chlorine, contact times necessary to attain the desired bacterial disinfection are shorter when using ozone. Under conditions which produce viral inactivation using ozone (maintenance of 0.4 mg/L of residual ozone over four minutes -- see next paragraph), bacterial disinfection will be attained simultaneously.

Viral Inactivation

Pioneering studies by French public health officials (Coin et al., 1964, 1967) have established that poliomyelitis virus types I, II, and III can be inactivated above 99.9% when exposed to a dissolved ozone residual of 0.4 mg/L for a minimum period of time of four minutes. Subsequent to these studies, the city of Paris adopted the criterion of maintaining an 0.4 mg/L residual ozone over four minutes after the initial ozone demand of the water has been satisfied for viral inactivation. This standard subsequently was adopted throughout France when ozone is applied for disinfection. Ozone disinfection facilities in many other countries have been patterned after the French standard, and the World Health Organization recommends the same conditions for ozone disinfection. It should be understood, however, that only France has formally adopted these conditions as standard for ozone disinfection.

Post-Treatment After Ozone Disinfection

It was pointed out earlier that ozone does not provide a stable residual for the distribution system. Moreover, the addition of ozone to water simultaneously adds large volumes of air and/or oxygen to the water, because the concentrations of ozone in the gases exiting the ozone generator are only 1 to 3% when air is used as the feed gas, or 2 to 6% when pure oxygen is the feed gas. Thus the act of ozonation results in significant increases in the dissolved oxygen content of the water.

Finally, it should also be appreciated that when ozone oxidizes dissolved organic components of water supplies, those organics are seldom oxidized totally to CO_2 and water. Instead, the organic materials are partially oxidized, and the partial oxidation products contain more oxygen than did their precursors. As a general rule, partially oxidized organic compounds are more biodegradable than the initial materials. They have been started along their way to complete oxidation, ultimately to produce CO_2 and water.

Because of the above consequences of ozone disinfection, it is clear that without a stable ozone residual for the distribution system, along with a higher dissolved oxygen content and with a higher content of biodegradable, partially oxidized organic constituents, the distribution system now becomes a "garden of Eden" for bacterial regrowth. This type of regrowth was, in fact, observed in Swiss distribution systems when ozone disinfection was installed as the terminal treatment step. As soon as the causes of regrowth were recognized, however, addition of a small residual of chlorine dioxide was adopted (about 0.15 mg/L). This prevented bacterial regrowth from occurring in the distribution systems (Miller, et al., 1978).

There can be interactions between chlorine dioxide and ozone, however, and for this reason, many Swiss water treatment plants using ozone for disinfection, routinely filter ozonized water through granular activated carbon prior to addition of chlorine dioxide. GAC serves the dual purpose of destroying excess ozone in the water and adsorbing many of the remaining organics in the water, thus providing an even higher quality of drinking water (Rice et al., 1982).

Ozone Oxidation of Soluble Iron and Manganese

Ferrous iron is rapidly oxidized by ozone to ferric ions, which then hydrolyze, coagulate, and precipitate as the insoluble ferric hydroxide, according to the following equations:

$$Fe^{+2} + O_3 + H_2O \longrightarrow Fe^{+3} + O_2 + 2(OH)^-$$

$$Fe^{+3} + 3H_2O \longrightarrow Fe(OH)_3\downarrow + 3H^+$$

Similarly, divalent manganous ions are easily oxidized to the tetravalent manganic ions, which then hydrolyze rapidly forming the insoluble manganese dioxide:

$$Mn^{+2} + O_3 + H_2O \longrightarrow Mn^{+4} + O_2 + (OH)^-$$

$$Mn^{+4} + 4(OH)^- \longrightarrow Mn(OH)_4 \longrightarrow MnO_2\downarrow + 2H_2O$$

However, excessive ozonation of manganese compounds will continue the oxidation process, producing the soluble septavalent, permanganate ion, which is pink in color:

$$Mn^{+2} \text{ or } Mn^{+4} + 4O_3 \longrightarrow MnO_4^- + 4O_2$$

Permanganate is toxic, and must be prevented from entering water distribution networks, where it is slowly reduced to insoluble MnO_2, leading to buildup of manganate scales. To avoid this possibility, ozonation for oxidation of iron and/or manganese normally is conducted prior to filtration, at an early stage in the water treatment process. Holding the ozonized water 30 minutes allows traces of permanganate to oxidize some of the organics present, and be reduced to the insoluble tetravalent state:

$$MnO_4^- + \text{organics} \longrightarrow MnO_2\downarrow + \text{oxidized organics}$$

Decomplexing of Organically Bound Heavy Metals

When decaying vegetation is present in raw water supplies, there is a strong possibility that heavy metals, particularly manganese, can be present in the form of soluble organic complexes. Such complexes are not easily decomposed by chlorine, but ozonation easily liberates the heavy metal as a soluble cation. For this type of application, ozonation is conducted at an early stage in the treatment process, before filtration.

Oxidation of Inorganics (Cyanides, Sulfides, Nitrites, and Ammonia)

Toxic cyanide ions are readily oxidized by ozone to the much less toxic cyanate ion:

$$(CN)^- + O_3 \longrightarrow (CNO)^- + O_2$$

Cyanate ion slowly hydrolyzes to produce CO_2 and nitrogen:

$$2(CNO)^- + 2H_2O \longrightarrow 2CO_2 + N_2 + 4H^+$$

Sulfide ion is easily oxidized to sulfur, then to sulfite, then to sulfate:

$$S^{-2} + O_3 \longrightarrow S^o \longrightarrow SO_3^{-2} \longrightarrow SO_4^{-2}$$

The degree of oxidation obtained will depend upon the amount of ozone employed and the contact time.

Nitrite ion is oxidized very rapidly by ozone to nitrate ion:

$$NO_2^- + O_3 \longrightarrow NO_3^- + O_2$$

Oxidation of these inorganic species will occur at any stage of the treatment process at which ozone is applied. Since the products of ozonation all are soluble (except for elemental sulfur from sulfide oxidation), there is no particular advantage to be gained in applying ozonation at any specific point in the treatment process, as is the case for oxidation of organics and for disinfection.

Under pH conditions normally found in water treatment plants, ammonia does not react with ozone at any appreciable rate below pH of 9.0 (Singer & Zilli, 1975). Therefore, ammonia in the raw water supply will carry through the plant, unless it is converted to nitrate biologically (nitrification - see section on Ozone Pretreatment for Biological Processing). Levels of ammonia generally are undesirable in finished waters because ammonia combines with free chlorine to produce chloramines, which are less beneficial as disinfectants than is free residual chlorine. However, chloramines do exert sufficient bacteriostatic action to be useful in distribution systems for residual.

Oxidation and Removal of Organics

Color Removal - Usually the colors present in drinking water are derived from the decomposition of naturally occurring humic materials, and are caused by the presence of conjugated unsaturated moieties, called chromophores. Ozone is particularly reactive toward unsaturated groups, cleaving the carbon-carbon double bonds to produce ketones, aldehydes, or carboxylic acids, depending upon the other substituents on the carbon atoms affected, the amount of ozone applied, the ozone contact time involved, temperature, etc. As soon as the conjugation has been disrupted by ozone, the color disappears. However, this does not mean that all of the color-causing compound has been totally oxidized to CO_2 and water. Instead, the original organic material has been partially oxidized, and now contains a large number of polar, oxygen-containing groupings.

These polar groupings now can combine with polyvalent cations, such as aluminum or ferric ions, added as flocculating agents, and thus can be easily precipitated from the treated water. Therefore, when using ozone for color removal, it should be applied prior to chemical addition and followed by filtration.

Oxidation of Other Organics - Organic compounds which cause taste and odor problems (many phenols, metabolic products of algal metabolism), and some detergents and pesticides can be oxidized partially upon ozonation. In most cases, this amount of oxidation is sufficient to destroy the undesirable organoleptic properties imparted to the water by the particular contaminant. Total oxidation rarely occurs, but the more polar oxidation products now are more easily flocculated and removed from solution. Consequently, ozonation for these purposes also should be conducted before chemical treatment and filtration.

Algae Control - During seasonal climate changes and when proper nutrient balances are present in the raw waters, algae growths are promoted in the presence of sunlight. Large amounts of algae will clog filters in the treatment plant, requiring more frequent backwashing. Ozonation disrupts the metabolic processes of many types of algae by oxidizing key organic constituents.

In treatment plants already employing preozonation for other purposes, seasonal blooms of algae in the raw waters are handled merely by increasing the preozonation dosage for as long as the algae bloom lasts (usually only a few weeks). In plants employing ozone for disinfection, seasonal blooms of algae are controlled by adding a contacting basin to the early stages of water treatment and are preozonizing at this point.

Turbidity Control and Microflocculation - When turbidity is caused by colloidal sized suspended solids, ozonation sometimes will change the chemical nature of the particle surfaces, allowing the particles to coagulate and settle. In such instances ozonation decreases the level of turbidity.

In other cases, such as when ozone disinfection is conducted on waters containing relatively large quantities of dissolved organics, the turbidity of the ozonized water sometimes will increase. This is because of the introduction of oxygen into the organic materials, producing carboxyl, carbonyl, and hydroxyl groups. These highly polar moieties now can combine with polyvalent cations also present, such as calcium, magnesium, iron, aluminum, etc., forming higher molecular weight structures, which now precipitate. This phenomenon of turbidity formation after ozonation has been termed "microflocculation" by Maier (1979).

If the level of dissolved organics is lowered prior to ozone disinfection, microflocculation is not observed. The Swiss practice of filtration following ozone disinfection guarantees removal of any turbidity resulting from microflocculation.

In 1984, the City of Los Angeles, California will start up what will be the largest drinking water treatment plant in the world to utilize ozone. Some 3,311 kg (7,300 lbs) per day of ozone will be generated from oxygen to treat 2.2 million m^3 per day (580 mgd, US) to lower turbidity to less than 0.3 unit. The ozonized and chemically treated (iron salts and cationic polymer) raw water will be coagulated, flocculated, then filtered through six-feet of anthracite coal at a rate of 13.5 US gal/min/ft^2. This high filtration rate is made possible by employing ozone as a microflocculant, without which filtration rates of the coagulated and flocculated water could not exceed 9 US gal/min/ft^2 (Stolarik, 1983).

Ozone Pretreatment For Biological Processing - Examples cited earlier pointed out that under ozonation conditions normally applied in treating drinking water, most oxidizable organic constituents are only partially oxidized. However ozone does introduce considerable oxygen into these compounds and renders them more biodegradable.

At the same time, ozonation increases the dissolved oxygen content of the water, thereby improving conditions for aerobic microbiological activity. Such biological activity can convert dissolved organic impurities to CO_2 and water, but also can convert ammonia to nitrate.

Post-ozonation biological treatment can be conducted in a variety of manners. Raw waters can be preozonized, then stored several days in a reservoir before entering the treatment plant proper. After entering the treatment plant, intake waters can be ozonized along with chemical addition, then filtered. Ozonation partially oxidizes dissolved organics, which then are more completely precipitated by means of the flocculating agents. In sand filters, some dissolved organic carbon is removed biologically. Nitrification also occurs in sand filters.

GAC filters/adsorbers placed after sand filter beds also contain considerable aerobic bioactivity. Those dissolved organic compounds which have not been oxidized, even by ozone, are adsorbed by the GAC. Other organics which have been partially oxidized during ozonation may or may not be adsorbed, but in any case also can be biodegraded by the microorganisms present.

Because of the increased biodegradation which occurs in the GAC adsorbers, the breakthough time for the GAC is postponed. In European water treatment plants which are employing this "biological activated carbon" process, it has been shown that the useful lifetime of the GAC can be extended by factors up to six times, simply by incorporating ozone oxidation prior to filtration through sand/anthracite.

Extension of the GAC operating life results in cost savings which, in some instances, have been shown to pay for the costs of installing preozonation. This aspect will be discussed further later in this paper under "costs".

Ozone Treatment of THMs or THM Precursors - When chlorine is added to water containing trihalomethane precursors, trihalomethanes (THMs) and other halogenated compounds are produced. Once formed, THMs are not oxidized, even by ozone. The more volatile THMs may volatilize partially, because of the aerating action which accompanies the application of ozone to water. Adsorption on GAC will remove THMs for a short time, but rapid breakthough is observed, requiring frequent reactivation of the GAC, which is a costly process.

It is axiomatic that once THMs are produced, chlorine has been wasted and THMs are costly to remove. Thus, the approach of the discerning water treatment engineer should be to modify his treatment process to minimize the concentrations of THM precursors before the addition of chlorine. This approach should be contrasted with that of making no changes in the treatment process, but installing treatment techniques to remove THMs after they are formed.

Ozonation has been shown to lower the concentrations of some THM precursors, but in several cases THM precursor levels actually increase upon ozonation (Rice, 1980). As a result, the use of ozone to oxidize THM precursors and reduce their concentrations should be tested on each water supply before this approach is adopted.

THM precursors can be partially oxidized by ozone, then flocculated with standard flocculating agents. Thus, preozonation of raw waters, followed by chemical addition, flocculation, sedimentation and filtration appears to be one effective approach to lower the concentrations of THM precursors, and therefore, the concentration of THMs ultimately produced. Since the water treatment objective is to minimize the amounts of halogenated compounds, then prechlorination must be abandoned in favor of precursor minimization techniques.

Summary

Figure 1 shows the "conventional" water treatment process, along with appropriate points of application of ozone for specific purposes. In this figure, the "conventional" water treatment process is defined as treatment of the raw water with chemicals (other than chlorine) for coagulation, flocculation, sedimentation, then filtration and disinfection.

When ozone is used as an oxidant, it is applied during early stages of the treatment process. When used as a disinfectant, it is applied as the last treatment step prior to adding the appropriate chlorine compound for residual. At any point of application, ozone will both oxidize and disinfect. In early stages of treatment, when levels of oxidizable materials predominate over microorganisms, only partial disinfection may be achieved, unless large amounts of ozone are applied in relation to the amounts of oxidizable materials present.

Conversely, when ozone is used as a disinfectant after removal of most of the oxidizable constituents, complete disinfection can be attained with small amounts of ozone. Under these circumstances, only small amounts of organic oxidation products will be produced. Therefore, ozone should not be relied upon as a disinfectant in the early stages of treatment.

TWO-STAGE APPLICATIONS OF OZONE

The benefits of applying ozone at more than one point in the treatment process have been pioneered in modern French and German plants, and several plants in the Paris suburbs recently have installed triple-stage ozonation to improve the quality of water even further. Triple-stage ozonation will be discussed in a later section.

Rouen-la-Chapelle, France

One of the first plants to use double-stage ozonation is the la Chapelle plant at Rouen, France (Gomella and Versanne, 1977). Figure 2 is a schematic diagram of the water treatment process employed. Water is drawn from wells adjacent to the Seine River (well downstream of Paris). Preozonation is conducted to oxidize iron and manganese, as well as to partially oxidize dissolved organic constituents and to prepare the medium for nitrification and biological removal of organics.

Following ozonation, the water is sand filtered. Precipitated iron and manganese hydroxides are removed and most of the ammonia is converted to nitrate biologically. Next, the filtered water is passed through granular activated carbon beds where most

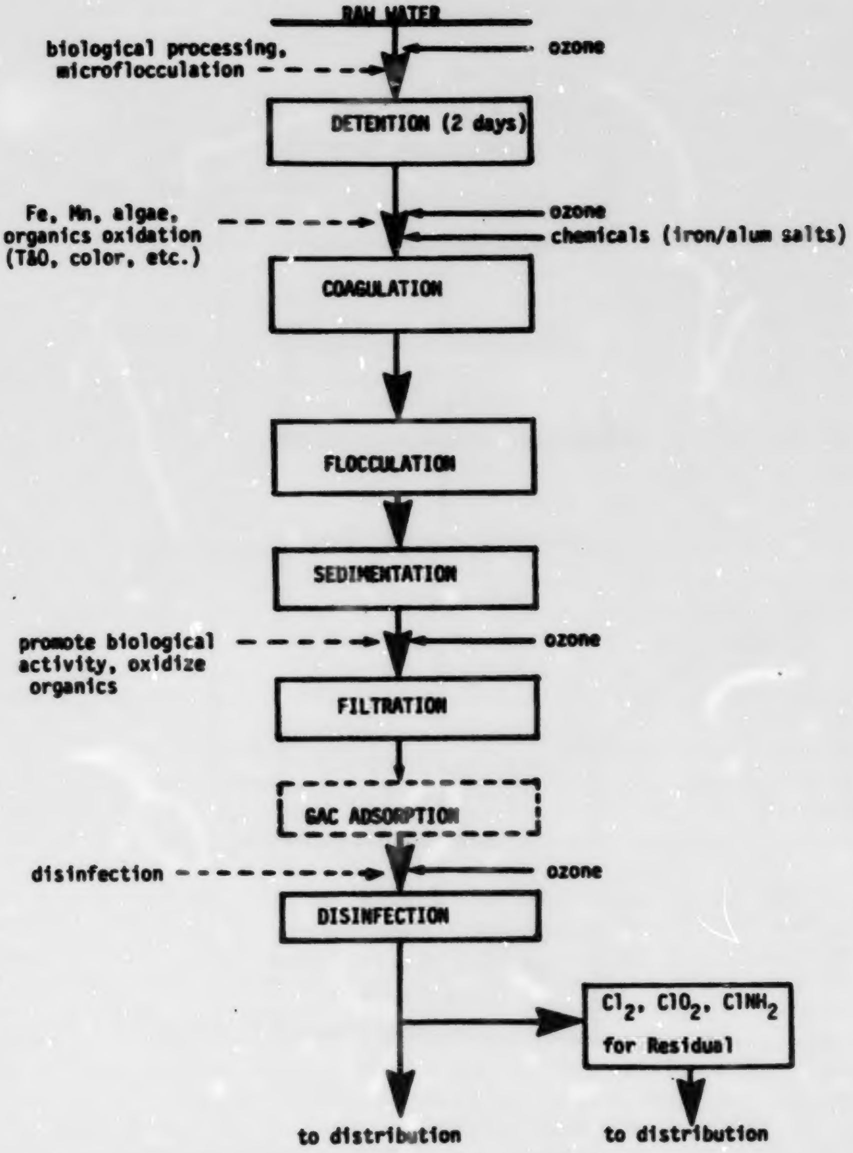

RAW WATER
biological processing, microflocculation
ozone
DETENTION (2 days)
Fe, Mn, algae, organics oxidation (T&O, color, etc.)
ozone
chemicals (iron/alum salts)
COAGULATION
FLOCCULATION
SEDIMENTATION
promote biological activity, oxidize organics
ozone
FILTRATION
GAC ADSORPTION
disinfection
ozone
DISINFECTION
Cl2, ClO2, ClNH2 for Residual
to distribution
to distribution

Figure 1. Points of ozonation during water treatment.

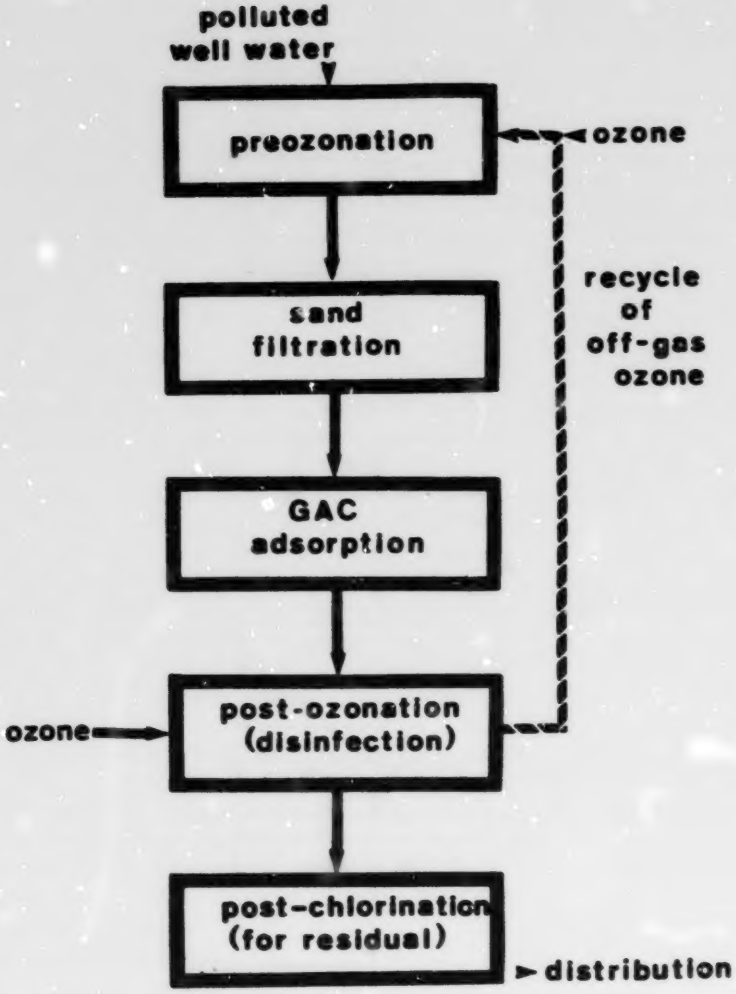

polluted
well water
preozonation
ozone
sand
filtration
recycle
of
off-gas
ozone
GAC
adsorption
post-ozonation
(disinfection)
ozone
post-chlorination
(for residual)
distribution

Figure 2. The Rouen-la-Chapelle process, Rouen, France.

of the organics are removed (by adsorption and biological degradation). Ozone disinfection, then post-chlorination for residual complete the treatment process.

Ozone disinfection is conducted in two contact chambers containing diffusion bubbling devices. These allow adequate ozone transfer efficiency to the water (90% and higher) without requiring additional energy beyond that necessary for the generation of ozone. In the first contact chamber, a level of 0.4 mg/L of residual ozone is attained during a retention time of five to six minutes. In the second chamber, the 0.4 mg/L level of residual ozone is maintained during another five to six minutes. About two-thirds of the ozone used for disinfection is applied in the first contact chamber (to satisfy the initial ozone demand) and the balance is added in the second.

Because the transfer efficiency of ozone into water in the bubbler diffuser contactor is about 90%, the exhaust gases from the ozone disinfection contactor still contain a significant amount of ozone. If disinfection were the sole purpose of ozonation, these exhaust gases would be passed through an ozone destruction unit before discharge to the outside atmosphere. However, because of the second application of ozone at this plant (preozonation), the disinfection contactor exhaust gases instead are drawn into the preozonation contact chamber by means of a turbine, which also serves as the ozone contacting device and for rapid mixing.

This use of contactor exhaust gases serves two purposes: first, it supplies most of the ozone required for the first stage, and second, it utilizes most of the ozone which otherwise would have to be destroyed without realizing any benefit.

During the preozonation step there is no requirement to develop a specific residual of dissolved ozone for a specified period of time, because the objective is oxidation, not disinfection. Oxidation of iron and manganese and the phenols (which are the primary organics present) is nearly instantaneous. Partial oxidation of other organics, while not instantaneous, nevertheless occurs in the short contact time (two minutes at Rouen). Thus the use of a turbine contactor device, which requires energy for its operation, is cost-effective for the preozonation step. Not only does it provide violent agitation of ozone with the water, but it also creates a partial vacuum which draws the disinfection contactor exhaust gases into the preozonation contact chamber, thus eliminating the need for additional pumping.

In the event that more ozone is required for the preozonation step than is available in the disinfection contactor exhaust gases, the additional ozone can be provided directly from the ozone generators.

It is also worth noting that this two-stage ozonation system which includes GAC adsorption was installed at Rouen instead of a process involving prechlorination, followed by filtration, GAC adsorption (to remove chlorine and chlorinated organics) then ozone disinfection. This decision was based on considerations of costs; the process involving chlorine would have required significant space for long detention time chlorine contacting. In addition, the GAC used for dechlorination would have required frequent reactivation (less than six months) (Gomella and Versanne, 1977).

After three years of successful operation, it has been reported that the GAC had shown no signs of breakthough of organics sufficient to require its reactivation (Schulhof, 1979).

Mülheim, Federal Republic of Germany

One of the first water treatment plants to employ two-stage ozonation in the Federal Republic of Germany, was the Dohne plant in Mülheim. This plant treats Ruhr River water by the process shown schematically in Figure 3 (Sontheimer, et al., 1978), which has replaced the original process involving breakpoint chlorination of the raw water. By the new process, raw water is treated with flocculating agents and ozone under high speed agitation. This not only provides the desired degree of mixing, but also allows effective contacting of ozone and partial oxidation and microflocculation of organic components.

After sedimentation, the supernatant water again is ozonized, this time in a two-chamber contactor with bubble diffusers using the French disinfection conditions similar to those employed at the Rouen-la-Chapelle plant. This treatment continues the oxidation of organic materials, making them all the more biodegradable.

Pure oxygen is added to the ozonized water to increase the dissolved oxygen level in order to maximize nitrification in the sand filters, and to promote aerobic biological activity in the GAC adsorbers.

As at the Rouen-la-Chapelle plant, exhaust gases from the second ozonation step are drawn into the preozonation stage for reuse/-destruction of ozone.

Suburbs of Paris, France

Gerval (1978) reported experiences of the Syndicat des Communes de la Banlieue de Paris pour les Eaux with preozonation of raw waters to improve biological removal of dissolved organics and conversion of ammonia to nitrate. In the large plants of the Paris suburbs where ozone disinfection had been in use for many years with conventionally treated Seine, Oise and Marne river

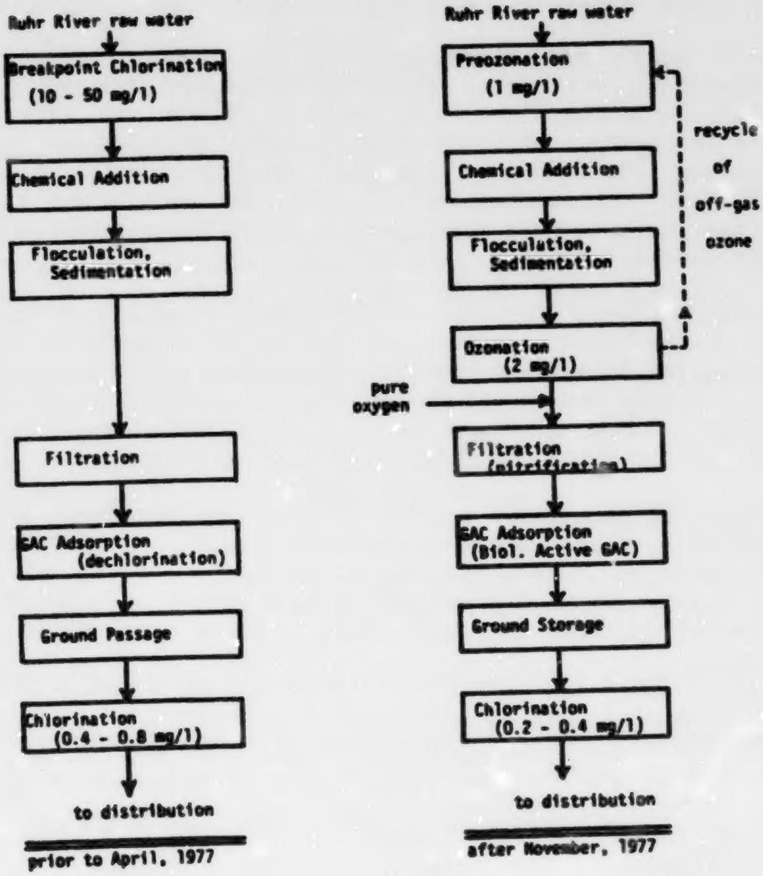

Ruhr River raw water
Breakpoint Chlorination
(10 - 50 mg/1)
Chemical Addition
Flocculation,
Sedimentation
Filtration
GAC Adsorption
(dechlorination)
Ground Passage
Chlorination
(0.4 - 0.8 mg/1)
to distribution
prior to April, 1977
Ruhr River raw water
Preozonation
(1 mg/1)
recycle
of
off-gas
ozone
Chemical Addition
Flocculation,
Sedimentation
Ozonation
(2 mg/1)
pure
oxygen
Filtration
(nitrification)
GAC Adsorption
(Biol. Active GAC)
Ground Storage
Chlorination
(0.2 - 0.4 mg/1)
to distribution
after November, 1977

Figure 3. Comparison of old (prechlorination) and new (two-stage ozonation) processes at Dohne plant, Mülheim, Federal Republic of Germany.

waters (including prechlorination), the levels of ozone normally required for disinfection historically averaged 2 to 4 mg/L. However, in summer, these values could rise to as high as 5 to 7 mg/L, primarily because of the presence of higher concentrations of ozone-demanding organics and increased microorganism activity.

When ozone was first installed at these plants, ammonia was removed by breakpoint chlorination of the raw water. However, with increasing levels of ammonia in the raw water, and with the increased production of halogenated organics during prechlorination, the treatment process had to be modified. The point of first introduction of chlorine has been moved to after the ozone disinfection step, and ammoniacal nitrogen now is being removed biologically.

Installations for biological removal of ammoniacal nitrogen at these plants consist of raw water reservoirs or detention tanks in which ozone-treated raw waters are stored approximately two days before entering the plant proper. The amount of ozone required for preozonation is small (less than 1.25 mg/L) and the contact time required is only two minutes.

Table II shows the effects of two-day reservoir storage with and without preozonation under the above conditions upon certain of the raw water quality parameters. Levels of detergents, organic carbon, COD and ammoniacal nitrogen are significantly lowered upon two-day storage preceded by preozonation.

TABLE II. EFFECTS OF PREOZONATION BEFORE STORAGE
(1.25 mg/L ozone dosage)

	detergents (mg/L)	organic carbon (mg/L)	COD (mg/L of oxygen)	NH_4^+ (mg/L)
raw water	0.16	8.3	19	6.2
2-day storage (no preozonation)	0.13	8	11	4
2-day storage (with preozonation)	0.08	7	6	3.2

Of even more significance was the fact that the preozonation dosage of 1.25 mg/L lowered the post-ozonation disinfection dosage from an average of 4.2 mg/L to 2.1 mg/L. Thus the total amount of ozone required at this plant has been kept the same (or even slightly reduced), while the only investment cost involved was the installation of a preozonation contactor system and the associated piping.

Further benefits resulting from this process modification are:

- a reduction in quantities of pretreatment chemicals formerly required,
- an approximately 50% increase in filtration cycle time,
- oxygenation of the water, which improves the elimination of nitrogen even further.

When the filter inlet ammoniacal nitrogen level is not greater than 1 mg/L, the outlet level does not exceed 0.1 mg/L.

Because of these benefits of preozonation, it is now possible for the plant to use less chlorine downstream for post-disinfection residual, which, in turn, lowers THM contents to below 10 mg/L in the distribution systems.

When the preozonation system was optimized at this Paris suburbs plant, it was found that the usual 4 mg/L ozone disinfection dosage (when this was the sole ozonation step) was reduced to 1.2 mg/L by applying an optimized preozonation dosage of 0.6 mg/L, an actual savings in total ozone requirement.

Since installation of two-stage ozonation in the Rouen-la-Chapelle plant in 1976 and at the Dohne plant in 1977, many other European water treatment plants have installed similar treatment processes.

Belle Glade, Florida

In the United States, the first two-stage ozonation water treatment plant is under construction at Belle Glade, Florida, and is scheduled to start operating in 1984 (Wagner and Elefritz, 1983). Raw water for this plant is taken from Lake Okeechobee, which has very high contents of humic color and other naturally occurring organic materials, turbidity and biological growths. Normally the lake waters exhibit COD levels in excess of 60 mg/L with TOC levels about 30 mg/L. After storms, these levels have risen to as high as 100 and 75 mg/L, respectively, with color levels peaking at 500 color units.

Historically, this raw water has been prechlorinated for algae control and partial color removal, followed by lime softening and treatment with alum, synthetic polymers, and recycled lime sludge, then recarbonation prior to filtration and chlorine disinfection. By this process, the Belle Glade plant normally produces total THM levels of 600 to 900 microg/L (ppb). Moving the point of chlorination was not effective, in that serious algae blooms then were encountered within the treatment plant. The respiratory products of the algae and of the saprophytic bacteria were not removed by the conventional treatment process, without prechlorination, and taste, odor, and additional THM problems resulted upon postchlorination.

Figure 4 shows a schematic of the new two-stage ozonation process which was developed for treating the Lake Okeechobee water at Belle Glade. Raw water is preozonized to modify the structure of the THM precursors, making them more susceptible to physical removal by means of added lime and polyelectrolytes after flash mixing. After clarification, the water is recarbonated for pH control, then post-ozonized to polish remaining organics, filtered to remove any remaining apparent color and filterable organic material, then post-chlorinated to develop a free residual of chlorine for the distribution system.

This process was demonstrated over a 12-week period in a 5-gal (U.S.)/min pilot plant unit. During this period of time, terminal THM concentrations were maintained below 100 microg/L (ppb) consistently. Using free chlorine disinfection, the THM content could be maintained as low as 25 ppb consistently. With combined chlorine residual, the THM content could be adjusted to even lower levels. During the same period of time, the conventional process generated 600 to 1,600 ppb of THMs in the main plant.

The total amount of ozone to be applied in the plant is about 6 mg/L, half of this being added during preozonation, the other half during post-ozonation. As a result of improved removal of organics (with control of algae and color as additional benefits), the post-chlorination disinfection dosage now will be about 2 mg/L. This dosage is sufficient to provide a stable free chlorine residual in the Belle Glade distribution system and to provide the very much lowered THM levels.

Wagner and Elefritz (1983) recommend that before initiating ozone testing, the plant process steps of mixing, clarification and filtration first should be adjusted to maximize efficiency(ies). At the Belle Glade plant, this included retrofitting clarifiers with vertical flow tube settlers to improve overall efficiency and capacity.

Canada

Plants at St. Rose and Point Viau, both in the Province of Quebec which already employ ozone for disinfection, are in the process of designing and installing preozonation (Larocque, 1984). These will be the first Canadian water treatment plants to adopt two-stage ozonation.

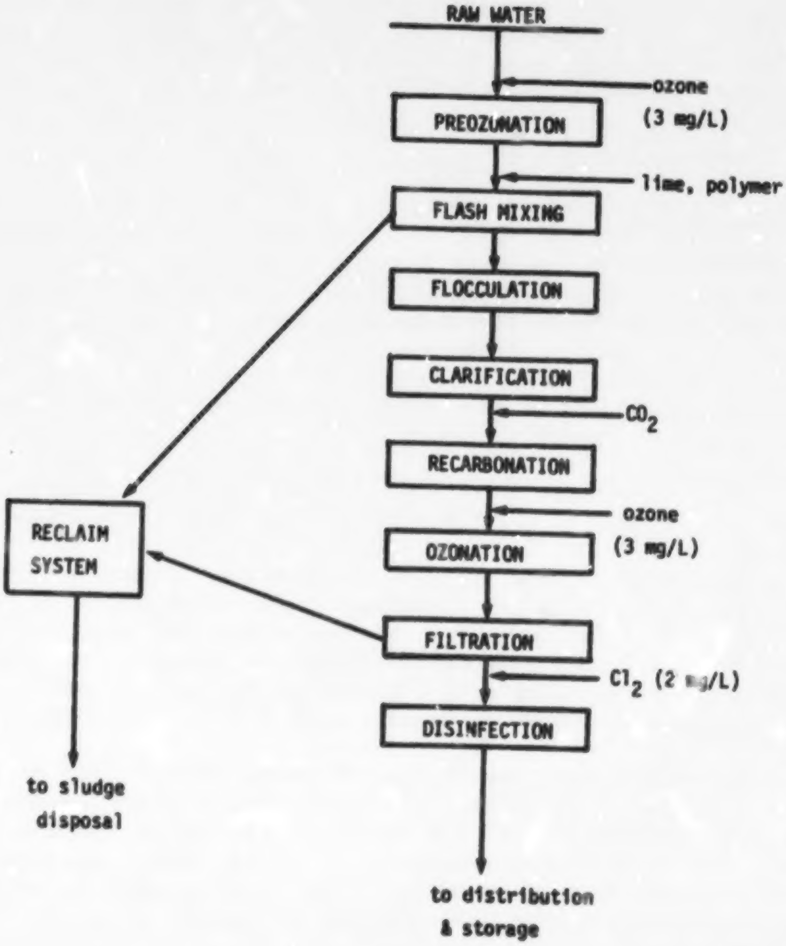

RAW WATER
ozone
(3 mg/L)
PREOZONATION
lime, polymer
FLASH MIXING
FLOCCULATION
CLARIFICATION
CO_2
RECARBONATION
ozone
(3 mg/L)
OZONATION
RECLAIM SYSTEM
FILTRATION
Cl_2 (2 mg/L)
DISINFECTION
to sludge disposal
to distribution & storage

Figure 4. The Belle Glade, Florida, two-stage ozone treatment system (Wagner & Elefritz, 1983).

TRIPLE-STAGE OZONATION

Following successful experiences with the promotion of biological oxidation of organics and nitrification of ammoniacal nitrogen by use of preozonation, triple stage ozonation was designed into three large water treatment plants in the suburbs of Paris, France during the period 1980-1981 (Schulhof, 1980). Recently, operational experiences with this new process have been described for the plant at Méry-sur-Oise (Rapinat, 1982). The three-stage ozonation process installed and operating at this plant is shown in Figure 5.

Raw water is preozonized using 0.25 mg/L ozone dosage, then allowed to stand several days in a storage basin. During this time settling occurs, as well as some biological decomposition of dissolved organic materials, and some nitrification. Following chemical treatment, flocculation, sedimentation, and sand filtration, ozone again is applied prior to GAC adsorption, and again a third time for disinfection after GAC adsorption. Chlorine for residual is added as the water leaves the treatment plant by means of sodium hypochlorite solution.

The original treatment process at Méry-sur-Oise (breakpoint chlorination, flocculation, sand filtration, ozone disinfection and postchlorination) removed 66% of the dissolved organics from the Oise river water. By the new process, involving three-stage ozonation, biological treatment, and elimination of the prechlorination treatment, 80% of the dissolved organics are removed and the product water contains no significant levels of trihalomethanes. Table III compares the effectiveness of the two processes in removing organic materials.

In the original process, the dosage of ozone required for disinfection averaged 3.5 mg/L. The new, triple-stage ozonation process requires a total of 4.5 mg/L. Total costs for the new process, including regeneration of the GAC every two years, are only 6% higher than those of the older, single-stage ozonation process. Relative costs for the two treatment processes are compared in Figure 6.

COSTS FOR OZONE TREATMENT OF DRINKING WATERS

In this section, costs are expressed in U.S. dollars and volumes are in cubic meters and U.S. gallons.

In surveying European and Canadian water treatment plants using ozone, Miller _et al._ (1978) found that capital costs for ozonation systems can range from a low of $1,100/kg ($500/lb) of ozone generation capacity per day for large systems to a high of $8,800/kg

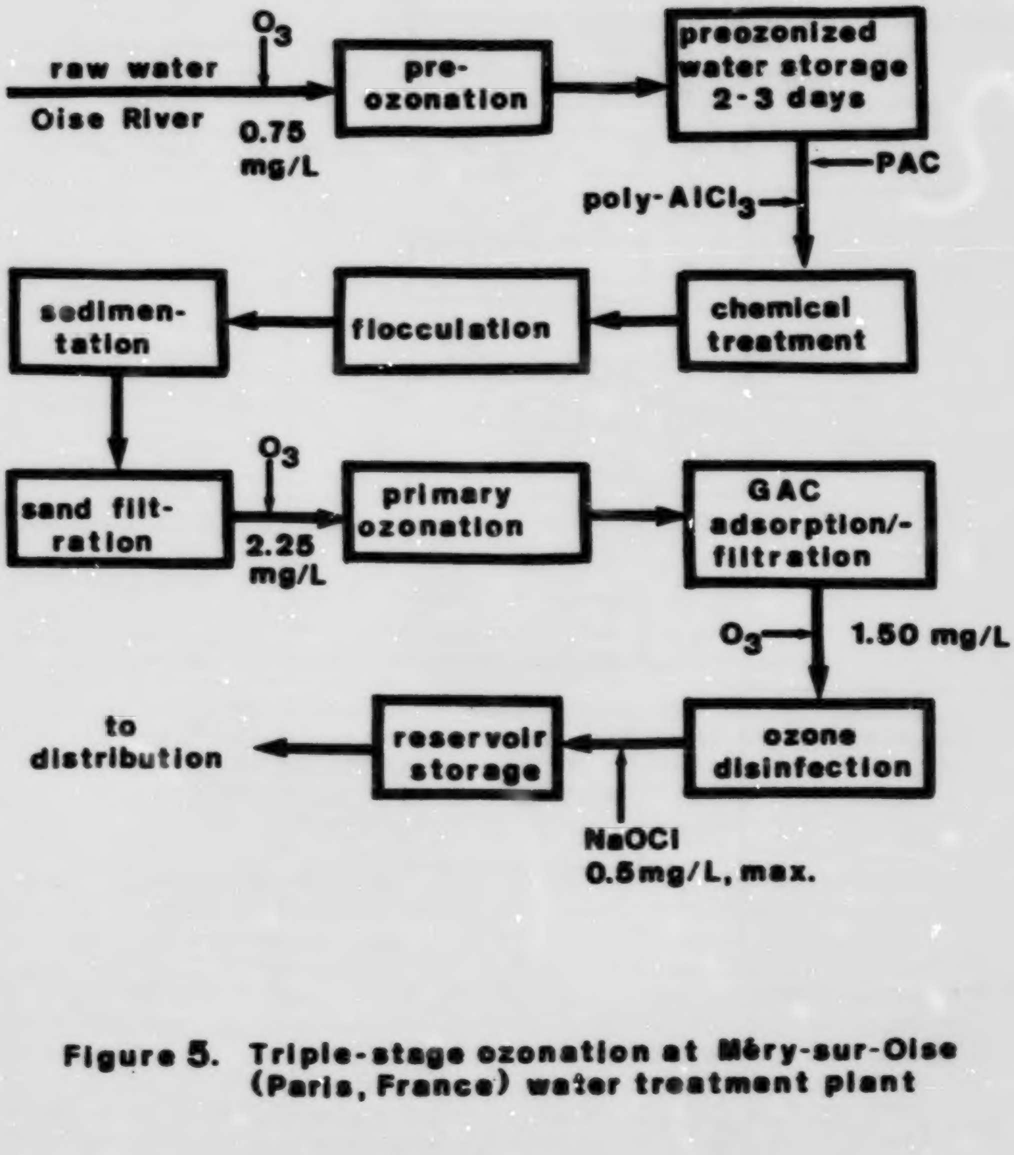

O_3
raw water
Oise River
0.75 mg/L
pre-ozonation
preozonized water storage 2-3 days
PAC
poly-$AlCl_3$
chemical treatment
flocculation
sedimentation
sand filtration
O_3
2.25 mg/L
primary ozonation
GAC adsorption/-filtration
O_3
1.50 mg/L
ozone disinfection
reservoir storage
to distribution
NaOCl
0.5mg/L, max.

Figure 5. Triple-stage ozonation at Méry-sur-Oise (Paris, France) water treatment plant

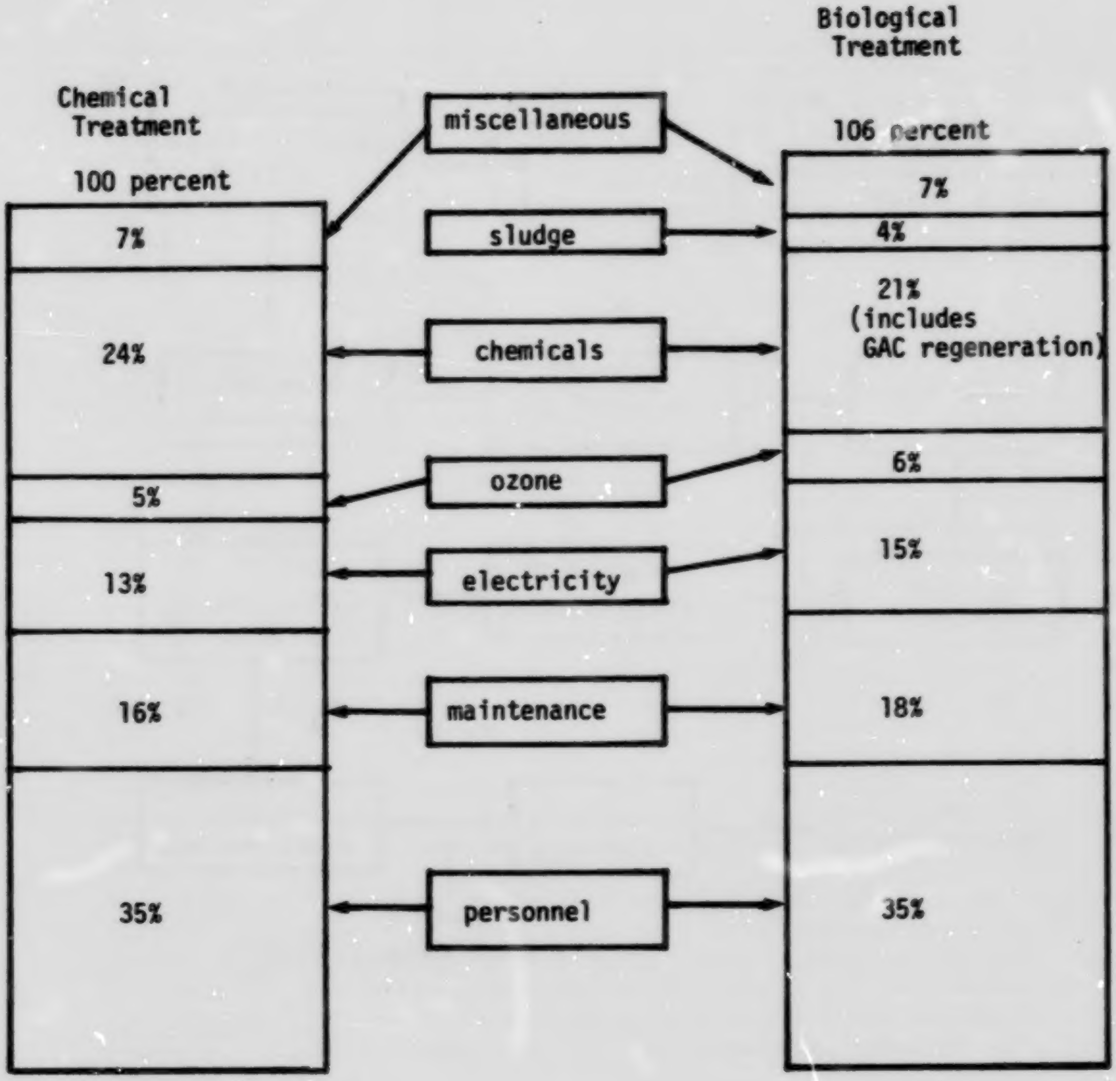

Chemical Treatment
100 percent
7%
24%
5%
13%
16%
35%
miscellaneous
sludge
chemicals
ozone
electricity
maintenance
personnel
Biological Treatment
106 percent
7%
4%
21%
(includes
GAC regeneration)
6%
15%
18%
35%

Figure 6. Comparative costs of chemical and biological treatment at Méry-sur-Oise (France) water treatment plant

($4,000/lb) per day for relatively small systems. Added costs are housing for the generating system, which can range from 20 to 33% of equipment costs, and contacting system costs.

TABLE III. ORGANICS REMOVAL AT MERY-SUR-OISE PLANT BY CHEMICAL AND BIOLOGICAL TREATMENT PROCESSES

	percent removal by	
after process step	chemical trtmt.	biological trtmt.
preozonation & storage	—	30%
flocculation & settling	—	45%
breakpoint chlorination & flocculation	50%	—
sand filtration	58%	60%
ozonation & post-Cl$_2$	66%	—
ozonation	—	68%
GAC adsorption	—	74%
post-ozonation	—	78%
post-chlorination	—	80%

Operating costs for ozonation systems depend upon energy demand, amortization rates, amortization period, and local energy costs. In surveying European drinking water treatment plants, Miller *et al*. (1978) found these costs to range from \$0.46¢/m^3 to 1.05¢/m^3 (1.75 to 4¢/1,000 gal) of water treated.

Lepage (1981) has described the 68,137 m^3/day (18-mgd) water treatment plant at Monroe, Michigan, which has been ozonizing for taste and odor control since early 1979. Two ozone generators, each capable of producing 113 kg/day (225 lbs/day) of ozone from dry air are in use. Total capital cost of the ozone generation and contacting system equates to \$2,310/kg (\$1,050/lb) of ozone generated. At an average applied ozone dosage of 1.63 mg/L to a 30,283 m^3/day (8-mgd) average flow rate and with an average ozone transfer efficiency in the contactor system of more than 97%, the total operating costs of air preparation, ozone generation, contacting, and reinjection of contactor exhaust gases have averaged 0.168¢/m^3 (0.636¢/1,000 gal) at Monroe.

It should also be noted that each of the two ozone generators installed at Monroe *can* handle the ozone demand of the system by itself if operated at its full production output. However, it is much more cost-effective to use both generators operated at less than full production capacity. The situation is analogous to operating an automobile at 100 miles/hr versus 50 miles/hr. At the slower speed, the energy demand is much lower.

When one ozone generator is taken off-line for preventive maintenance, the second generator is turned up to provide the ozone required for the few days involved.

At Bay City, Michigan, a 151,416 m^3/day (40 mgd) drinking water treatment plant has been operating since early 1980 for taste and odor control at an average flow rate of 45,425 m^3/day (12 mgd). Four ozone generators are capable of producing 250 lbs/day (113.4 kg/day) each, or a total of 1,000 lbs (453.5 kg)/day of ozone. Capital costs for installing these ozone generators were $660,800, which equates to $661/lb of ozone generation capacity. Operating costs for an average applied ozone dosage of 1.5 mg/L were reported to be 0.118¢/m^3 (0.448¢/1,000 gal) during the first six months of operation (Croy, 1980).

At New Ulm, Minnesota, 9,811 m^3/day (2.59 mgd) of well waters are treated with an ozone dosage of 2.1 mg/L to oxidize iron and manganese. The capital cost for the ozonation system capable of generating up to 34 kg/day (75 lbs/day) from dry air was $480,000 ($6,400/lb of ozone generation capacity; contacting costs are probably included in this figure) in 1982 dollars (Kirk, 1984).

In Potsdam, New York, a new 9,842 m^3/day (2.6 mgd) water treatment plant went on-stream in the summer of 1983 (Simcoe, 1983). Ozone is used for disinfection of river water prior to chlorination. In pilot plant studies, the THM maximum formation potential was lowered from 353 microg/L to 116 microg/L with applied ozone dosages of 2.5 mg/L. A single ozone generator produces 150 lbs (68 kg)/day of ozone from dry air.

Costs for the ozone generation equipment, including instrumentation and controls, is $227,600 ($1,517/lb of generation capacity). Ozone contactor chambers cost $194,400, of which $73,500 is for reinforced concrete structures, $55,000 for stainless steel covers, and $65,900 for stainless steel wall pipes, access manways, and drain piping.

Estimated annual operating costs for ozonation at this facility are estimated to be $20,000, consisting of $7,200 for ozone generation and thermal destruction of contactor exhaust gases, $4,100 for plant heating and ventilating, and $8,700 for equipment maintenance. These costs equate to 0.021¢/1,000 gal.

The City of Los Angeles conducted extended cost analyses on alternative treatment processes for controlling turbidity, taste and odor, reduction in levels of trihalomethanes and for assuring bacterial and viral disinfection (Stolarik, 1983). Their final decision came down to ozonation versus chlorination, and their determinant cost figures with regard to the two processes are shown in Table IV. By integrating ozonation into the filter plant design, a lower ultimate capital cost project results.

Annual operation and maintenance costs for ozone are higher than for chlorine, but the 50-year present worth (using a 9% discount rate) of the difference ($1,167,300) was less than the savings in plant construction cost due to the use of ozone.

An earlier present worth comparison between ozone and chlorine dioxide showed that the present worth cost of chlorine dioxide for this plant would be twice that of ozone.

At Belle Glade, Florida, the capital costs for equipment to generate 500 lbs (227 kg)/day of ozone, and to install the entire ozonation system, including contact reactors, piping, and a building to house the generators was $670,000 (Wagner and Elefritz, 1983). This equates to $1,340/lb of ozone generation capacity. Over 20 years at 12% compounded annual interest, this capital amounts to 3¢/1,000 gal of water to be treated.

Although the plant has not yet begun operating as of this writing, Wagner and Elefritz (1983) report that 12 kWh of electrical energy are required per pound of ozone generated to operate the ozone generating and contacting systems, and that future and peak demand power charges are estimated to rise to 9.5¢/kWh. Using these data and the expected total ozone dosage of 6 mg/L to a 6 mgd average daily flow, the power cost to generate the required ozone is 0.95¢/1,000 gal of water treated.

Table V summarizes the capital and operating cost data for ozone at the six U.S. water treatment plants discussed above. With the exception of the plant at New Ulm, Minnesota, the capital costs range from $661 to $1,517 per pound of ozone generation capacity. Operating costs for ozonation range from 0.021¢/1,000 gal at Potsdam, New York to an estimated 0.95¢/1,000 gal at Belle Glade, Florida. Both the capital and operating costs reported are significantly lower than those found for European ozonation systems by Miller et al. (1978).

ORGANIC OXIDATION PRODUCTS FROM OZONATION

Ozone oxidation of organic materials produces many intermediate oxidation products, as the carbonaceous materials progress along their oxidation pathways ultimately to produce CO_2 and water. As a general rule, these oxidized intermediates all contain more oxygen than did their precursors. Also as a general rule, the more oxygen organic compounds contain, the more water soluble and the more biodegradable they are. This is why ozone oxidation of organic materials promotes biodegradation.

TABLE IV. EFFECT OF OZONE VS. CHLORINE SYSTEMS COSTS ON TOTAL PROJECT COST* AT LOS ANGELES (Stolarik, 1983)

Capital Cost Item	Ozone	Chlorine
Process Equipment	$ 5,661,000	$ 166,000
Related Process Structures and Appurtenances	5,461,700	---
Additional Filtering Capacity (related costs)	---	13,070,330
Related Electrical	1,160,000	782,000
Additional Backwash Capacity	---	1,260,500
Miscellaneous	1,094,300	40,000
Subtotal	$13,790,800	$15,318,830
[Present construction provision for future facilities (O_3) should Cl_2 not achieve taste & odor control, THM standard]		
(including sales tax) TOTAL	$13,790,800	$18,532,830

Operation and Maintenance Item	Ozone	Chlorine
Chlorine	$ ---	$ 162,400
Additional Chemical Coagulant	---	314,000
Ozone Dielectric Maintenance	127,000	---
Additional Power	498,000	42,100
TOTAL	$ 625,000	$ 518,500

*Note: The costs reflect the difference between the alternatives as they affect the total project cost of the filtration plant, and do not include the costs for features which are the same.

TABLE V. SUMMARY OF OZONE CAPITAL AND OPERATING COSTS AT OPERATIONAL U.S. WATER TREATMENT PLANTS

plant (yr started)	size m^3 (mgd) per day	amt. of O_3 generated kg (lbs) per day	capital cost $/lb capacity	operating cost ¢/1,000 gal treated
Monroe, MI (1979)	68,137(18)	113(225)	$1,050	0.636¢
Bay City, MI (1978)	151,416(40)	454(1,000)	$ 661	0.448¢
New Ulm, MN (1982)	9,811(2.6)	341(75)	$6,400	not given
Potsdam, NY (1983)	9,842(2.6)	68(150)	$1,517	0.021¢
Los Angeles, CA (1984)	2.2MM(580)	3,311(7,300)	$ 716	0.295
Belle Glade, FL (1984)	22,712(6)	227(500)	$1,340*	0.95¢

* including costs of two-stage contacting + housing

Improved biodegradability also implies less toxicity of the oxidation products, but this is not always the case, particularly when aromatic rings are involved. With phenol, for example, initial oxidation takes place without cleaving the ring, and it should be assumed that the polyhydroxyaromatic intermediate oxidation products are as toxic as is phenol. Once the aromatic ring is ruptured, however, the aliphatic, carboxyl and carbonyl-containing products become less toxic, and more biodegradable.

Figure 7 shows many of the oxidative pathways which phenol undergoes when it is oxidized (Miller, *et al*., 1978). Included in this figure are dichlorinated phenols and alkylphenols, which are shown to produce the same oxidation products as phenol after ring rupture. The carbon-chlorine bonds are broken at some point during the oxidation process, generating chloride ions.

Although the reactions shown in Figure 4 are attributed to ozone oxidation, it should be appreciated that many of these intermediate oxidation products also can be produced by other strong oxidizing agents, including chlorine dioxide, permanganate, hydrogen peroxide, and chlorine itself.

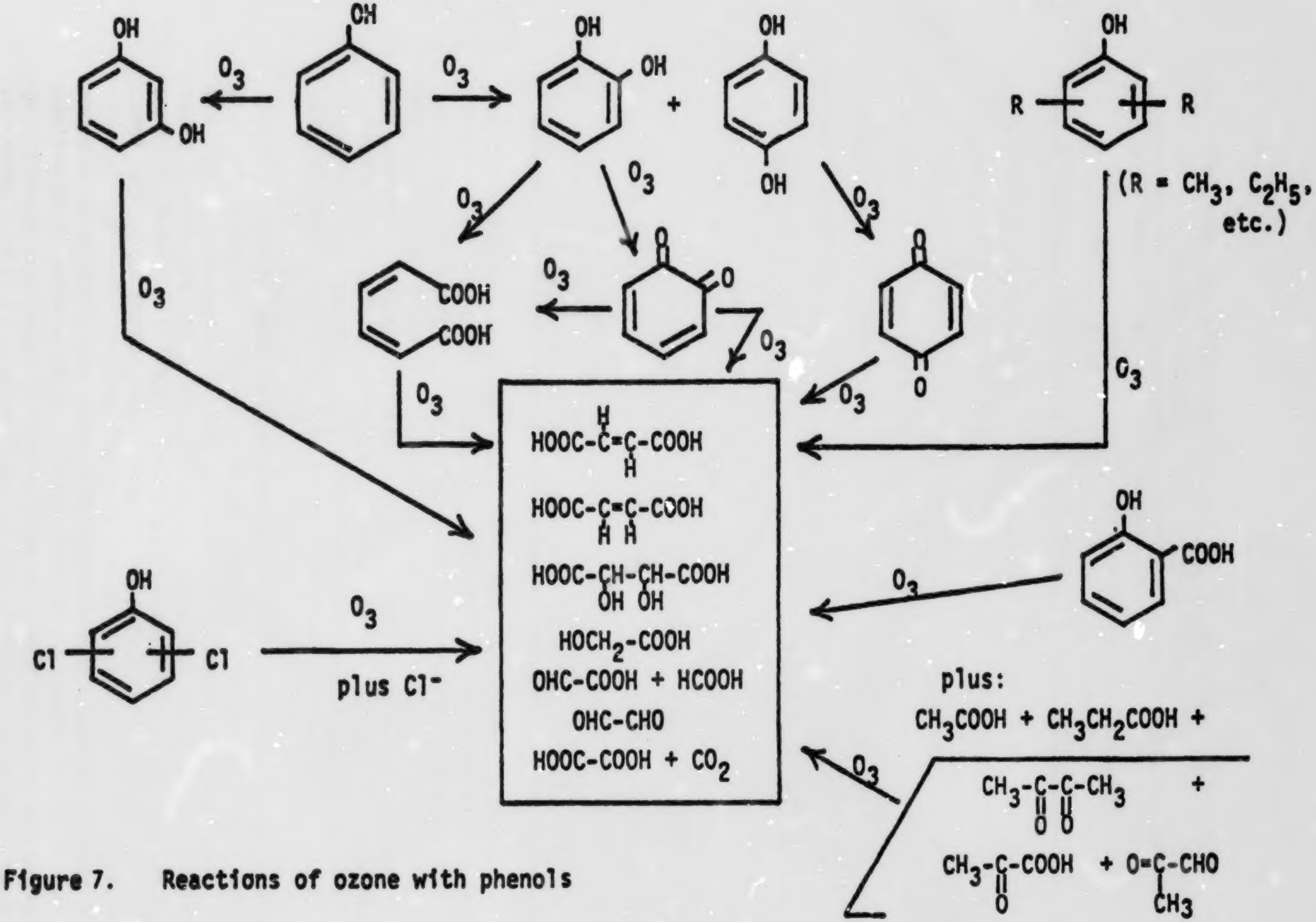
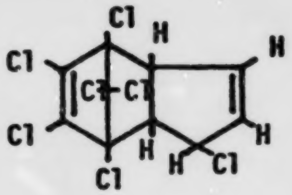

OH
OH
O_3
OH
O_3
OH
OH
+
OH
OH
OH
R
R
(R = CH_3, C_2H_5, etc.)
O_3
O_3
O_3
O_3
O
O
O
O
O_3
COOH
COOH
O_3
O_3
O_3
O_3
HOOC-CH=CH-COOH
HOOC-CH=CH-COOH
HOOC-CH(OH)-CH(OH)-COOH
$HOCH_2$-COOH
OHC-COOH + HCOOH
OHC-CHO
HOOC-COOH + CO_2
OH
COOH
O_3
OH
Cl
Cl
O_3
plus Cl⁻
plus:
CH_3COOH + CH_3CH_2COOH +
CH_3-CO-CO-CH_3 +
CH_3-CO-COOH + O=C(CH_3)-CHO
O_3

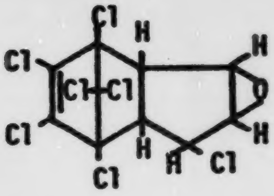
Figure 7. Reactions of ozone with phenols

Certain pesticides, such as parathion and malathion form their respective oxons upon initial oxidation. Further oxidation (using more oxidant and/or longer contact times) will convert these intermediates to other products, as shown in Figure 8. However, it should be appreciated that the oxons are more toxic than are the thions (Martin and LaPlanche, 1977).

The strong insecticide Heptachlor upon ozonation produces the more toxic Heptachlorepoxide, which is stable to further treatment with ozone under conditions normally employed in drinking water treatment plants (Hofmann and Eichelsdörfer, 1971).



heptachlor



heptachlorepoxide

These pesticide examples lead to several significant conclusions:

1) To the maximum extent possible, the water treatment specialist should know what oxidizable materials are in his raw water, and what products are formed upon oxidation,

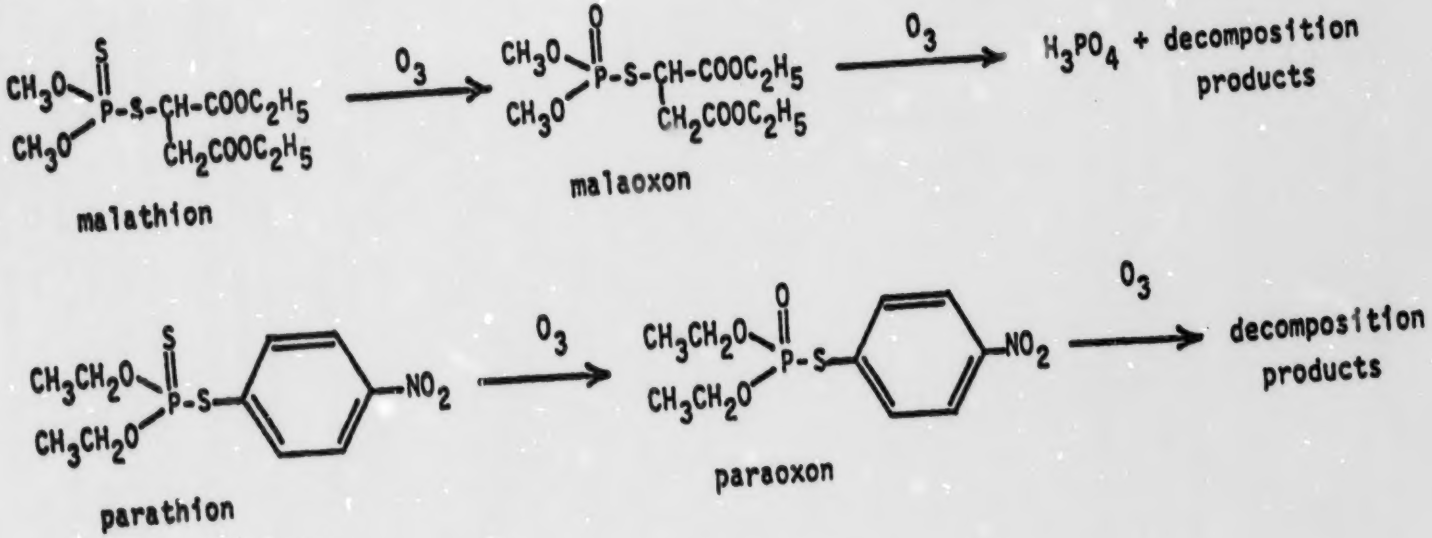
2) If ozone, the most powerful oxidizing agent employed in drinking water treatment, will not totally oxidize some organic compounds to CO_2 and water, neither will weaker oxidizing agents,

3) The application of any oxidizing agent to waters containing high concentrations of dissolved organic materials will produce organic oxidation products.

4) The proper water treatment strategy should be to remove organic materials to the maximum extent possible by physical and chemical techniques before any oxidant is added.

In reviewing the published literature on the oxidation products of organic materials produced by ozone or by chlorine dioxide, Miller et al. (1978) concluded that, as a general rule, all oxidants used for treatment of drinking water (chlorine, chlorine dioxide, permanganate, and ozone) can produce similar, and in some cases identical, non-halogenated oxidation products. Each oxidant will produce other organic oxidation products that are unique to its chemistry, such as halogenated organics when using chlorine, and from chlorine dioxide under certain conditions.

Figure 8. Ozonation of Malathion and Parathion


malathion
O_3
malaoxon
O_3
H_3PO_4 + decomposition products
parathion
O_3
paraoxon
O_3
decomposition products

Source: MARTIN & LAPLANCHE, 1977

This conclusion is supported by the work of Carlson and Caple (1977) who studied the oxidation of a variety of organic compounds (alpha-terpineol, oleic acid, abietic acid and cholesterol) with chlorine and with ozone in aqueous solutions. Many of the oxidation products isolated and identified were identical, regardless of which oxidant was employed.

CONCLUSIONS

1) The use of ozone for treating drinking water is a common practice, primarily in Europe where its use was pioneered in the early 1900s. Today there are at least 1,300 ozone water treatment plants throughout the world, 40 to 50 plants in Canada and 17 in the United States, successfully employing ozone for one or more purposes.

2) Ozone serves both as a disinfectant and as a chemical oxidant, and both processes will be operative regardless of where ozone is added during the treatment process.

3) When used as a disinfectant, ozone is applied at or near the end of the treatment process; when used as an oxidant, ozone normally is applied at an early stage.

4) Because ozone does not provide a stable residual for distribution systems, a chlorine compound (chlorine, chlorine dioxide or chloramines) normally is added for this purpose after ozone disinfection.

5) The ability of preozonation to partially oxidize organic materials in raw waters leads to their more efficient removal by subsequent flocculation and filtration. In many cases, preozonation saves chemical costs. At the new Los Angeles, CA plant, preozonation with chemical treatment allows a 50% faster filtration rate.

6) Most organic materials cannot be oxidized completely to CO_2 and water under ozonation conditions normally employed in water treatment plants. Partial oxidation products generally are more biodegradable than the original compounds. Thus ozonation can be used to promote biological activity, which when properly designed and operated within the water treatment plant, can lower the total organic carbon and ammonia contents of the treated water.

7) Plants already using ozone for disinfection can incorporate preozonation at the incremental cost of adding a preozonation contacting system. Ozone-containing exhaust gases from the disinfection contactor generally provide the requisite amount of ozone for the preozonation step.

8) Preozonation has replaced breakpoint prechlorination at many European water treatment plants, thus moving the point of chlorine addition until much later in the treatment process, after most of the organics have been removed. This results in much lower quantities of halogenated organics being produced.

9) Installing ozonation prior to GAC adsorption can prolong the useful life of the GAC up to a factor of six times. In many instances these savings in GAC reactivation can pay for the costs of preozonation.

10) The most modern French water treatment plants now are employing triple-stage ozonation (preozonation, ozonation prior to GAC adsorption, and ozone disinfection) to produce high quality drinking waters. This is being accomplished with less than 30% more ozone than that originally required for disinfection alone.

11) Although the capital costs of installing ozonation equipment are relatively high compared with other oxidants, operating costs are low. Capital costs for ozone generation in some of the newer U.S. water treatment plants range from $661 to $1,500 per pound of daily ozone generation capacity. Operating costs at the same range from 0.02¢ to 0.95¢ per 1,000 U.S. gallons treated.

12) Whenever any chemical oxidant is added to waters containing high concentrations of dissolved organic materials, oxidation products will be formed. Although each chemical oxidant produces organic oxidation products specific to its oxidation chemistry, many of the same products are formed by all chemical oxidants. Minimizing the formation of organic oxidation products requires maximizing the removal of organics by physical and chemical techniques before oxidants are added.

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DR. LEE WIKSTROM

WATER QUALITY ASSOCIATION

POINT OF USE FILTERS

"Point of Use Filters"

Dr. Lee Wikstrom,
Water Quality Association

Thank you, Kelly! On behalf of the Canadian Water Quality Association, I would like to thank the sponsors of the conference for giving us the opportunity to discuss the point of use of alternatives.

I am sure that all of you are familiar with at least one type of currently used device or another. But I am sure that all of you are not familiar with the categories of water treatment devices, their intended application and their effectiveness. One of the bottom lines is: the intended application - know the water quality and knowing the contaminant that is to be removed. There are devices available to remove most contaminants in water, and to address aesthetic effects as well - contaminants in water.

I run through the categories briefly. We have the faucet-mounted type of unit which is a small unit mainly intended - there is one, I am sure, that everybody has seen - to improve the aesthetic qualities of water. Normally, they are activated carbon in conjunction with mechanical filtration. You can see their effectiveness is relatively low. They are intended to be aesthetic devices and not address health questions. The health question - the immediate crisis when somebody finds out that their water is contaminated would be the major issue of everybody here today.

The next type of unit would be the faucet-attached unit. This has a hose that connects on to the faucet and will sit on the counter. One type of device which includes carbon and mechanical filtration. Another type of device which includes carbon and ultraviolet. You can see at the bottom there a connection which will go to your hose. The faucet-attached bottles have a greater degree of application. Again, they are mainly activated carbon and mechanical filtration. However, there are distillation units, ozone and chlorine-generation units of this type. The application here would be mainly tast and odour, and that would be activated carbon, and stills for addressing the total dissolved solids, THM and THO removal by activated carbon. The effectiveness of this type of unit, depending upon the size, the residence time, other design factors, would be between 10 and 99 percent.

The next category would be the in-line filter for the cold water tap usually in the kitchen. They come in different sizes. Here we have a 20-inch and a 10-inch housing with various types of cartridges that can be put into these housings. The in-line filters are mainly mechanical filtration, activated carbon and activated alumina. They address turbidity, taste and odour, and organics and TCE. And again, the range of percent removal is quite broad depending on the type of unit that you are looking at.

The next category would be the line-bypass unit. This type of unit mainly has the most engineering of all the units at this point in time. There are quite a number of sophisticated units on the marketplace to address most contaminants. Here is one type of unit, one of the manufacturers incorporates two, cylinders in series, and that fits under your sink. The various types of technologies used in line bypass would include activated carbon, mechanical filtration, reverse osmosis, alumina, and ion exchange, depending upon the contaminant to be addressed. Again, the TNO would be addressed by activated carbon, total dissolved solids by reverse osmosis, THM's and VHO's by activated carbon or activated carbon in a hybrid system with reverse osmosis. And fluoride would be removed by activated alumina.

The last category of units would be entire-home unit. In many instances, one does not want to encounter the vapours from water in the shower. Benzene would be a perfect example of this. Inhalation of benzene is probably worse than ingestion. So if you have a benzene-contamination problem or a high concentration of VHO, one would want to consider a whole-house system to remove the possibility of inhalation. One type of of unit is like a water softener tank with various media put into the tank instead of the ion exchange resins.

There is another type of unit - this is mainly a commercial-type unit - the types of units like these have been applied in the home with powdered activated carbon. Again, we have ion exchange in the whole house which normally we think of of softening. But with respect to health-effect contaminants, we are talking about radium and barium removal, are activated carbon to address the organics; mechanical filtration to remove turbidity, and reverse osmosis for most of the heavy metals and some of the heavy organic materials. We have magnesium greensand for iron removal which I think most of you are familiar with; activated alumina for fluoride; calcium carbonate for PH adjust; and chlorine and ozone injectors and ultraviolet for microbiologic control.

Then we have more of the applications: hardness, TNO, VHO, and the pesticides. Again, the range of effectiveness of this type of unit depends upon the design of the unit and the contaminant to be removed. Again I want to emphasize that knowing the contaminant and confirming the contaminent is the critical item.

So this can be put into three categories: the manufacture of them would be mechanical filtration, activated carbon and reverse osmosis units. This makes up the majority of the marketplace.

There is a wide range of materials of construction for this type of unit. There are metals, there are plastics, there is fiberglass in the range from the very small to the very large. The integrity of the material is quite critical in that you don't want the thing to blow up and flood your house. Most reputable manufacturers will have a well-designed unit because you don't stay in business very long if you replace floors all the time.

For the activated-carbon types of units: one thing I would like to say about activated carbon is that activated carbon is different from activated carbon is different from activated carbon. In addressing an organic contaminant problem, it is critical that the activated carbon be chosen properly and that the unit be tested for effectiveness against the contaminant in question. That is a critical item because there are carbons for broad ranges of application. The hardness of carbon is important from the point of view of getting a little bit of black carbon out when you install the unit. There are absorption differences. There are size differences. And I want to emphasize that it is critical that the carbon be proper for application.

For reverse osmosis, the same thing is true. The type of membrane is critical. For simple total dissolve solid removal, the cellulose acetate and the cellulose triacetate membranes work quite nicely. When you want to go organics of lower molecular weight, these particular membranes do not reject as much of the materials as one would like. Some of the newer polyuria and polysulfone composite membranes do a much better job for this application. So if you have an application, you have to, number one, know what the contaminant is, then choose the appropriate membrane. Reverse osmosis membranes work a lot better with higher pressures. If you have a large pressure differential across the membrane, you can get very good rejection rates. If you have a low pressure differential, your rejection rates drop off quite dramatically. So it's important to know what kind of pressure you have available or if you choose a system with a pump. Then looking at the system: knowing what the membrane will do is one thing; but knowing what the membrane will do in the system with a bladder tank is something altogether different. So be sure that you have performance data with reverse osmosis systems on the system itself; just not on the membrane!

The are a number of ways of assuring and monitoring the performance of a point-of-use device. Some devices have meters and controls that will shut the unit off after a predetermined number of gallons. Others have service rider where the dealer will come around and make sure that your unit is functioning properly, perform an analytical test, if possible, look at the number of gallons that you have used by the use of a water meter. So there are ways of assuring that the product will perform and continue to remove the contaminant in question.

Okay, product selection! Let's assume that like yesterday, we were in a real-world situation and you have become convinced that you have a water contamination problem. I want to say "convinced" - improve it. There are many products on the market that work very nicely, there are some that don't! How do you select? The U.S. Government had the same question. So they tested a number of point-of-use devices to see exactly their effectiveness in removing PHM's through the Gulf Search Research Contract. There were quite a number of devices tested. In the first phase of this study, only ome of the devices tested was intended for the removal of THM's. That device performed very nicely, removed on the order of 95 percent of the THM's over the recommended life of the unit. The remainder of the units were aesthetic application units and their performance, needless to say, was rather low for THM removal.

Phase 2 of this same study was continued on new types of units that were intended for THM removal. The units in question were mainly line-bypass units. There were a few stationary units and, again, we had a larger number of units intended for this application and the performance was accordingly high.

In the continuing study, VHO's and pesticides were investigated as these units removed THM's very nicely, the question was did they remove VHO's and pesticides. Two areas which were looked at were groundwater which would have TCE, PCE, carbon tet, and 1:1:1 trichloroethane. And again, as expected, the units that removed THM's and were designed for this application removed the contaminants quite nicely. For service water with chlordane, peradichlorobenzene and hexachlorobenzene, the performance of the units was not as good as for the volatile halogenetic organics. Again, the units were designed more for THM and volatile organic removal and these are different categories of organics, different molecular weights - therefore the carbons were not as effective for the removal of these contaminants.

The continuation of this study would be a demonstration study. Our company started a demonstration two and a half years ago now in Rockaway, New Jersey, with the Township of Rockaway. We looked at wells in a community where it would cost on the order of 3 million dollars to bring in municipal water to 300 homes. A number of homes were put on selected homes which had TCE, 1:1:1 trichloroethane, 1:2 trichloroethane, 1:2 trichloropropane. The results were quite dramatic in the ability of units this type to remove the type of contaminant.

U.S. E.P.A. out of Cincinnati, at the point in time, had a contract with the National Sanitation Foundation for the removal of fluoride from drinking water in Arizona and in the mid-west. The study was expanded to include VHO's and the continuation of the Rockaway Program is in progress, and a new study in Silverdale, Pennsylvania, on a distribution system with 50 homes is in progress. There are a number of different types of units and the performance of the units is being monitored and the operational costs, installation costs, capital costs are also being investigated to see how point-of-use [units] can be used to solve contamination problems and if it is indeed economically feasible to go in this direction.

At the same time, the Water Quality Association addressed the same point. When would point-of-use be the choice over central treatment bringing in water from outside, bottled water. The Water Quality Association contracted with the consulting firm of Temple, Barker and Sloane to address this question. A number of scenarios were addressed, one being if we only treat water for drinking, and that would be two gallons per day, if we only had a single tap which would deliver between half a gallon and two gallons per minute, or we address the whole house system at give gallons per minute. In this study, the various processes available were defined and the availability of commercial product was discussed. The types of technologies, as you have seen before, would be mechanical filtration, or ion exchange, activated carbon, and alumina. This study is addressing only contaminans that are in the Interim Primary Drinking Water Regulations. The cost figures - if you look at ion exchange - do not represent softening.

In one part of the study, which I am discussing now, we looked at costs: the equipment cost, the operation cost, and maintenance cost of these devices for the scenarios in question and we compared them to the central treatment plant. For anion exchange, again this is for barium and radium removal, for if you use a small system for drinking water only, it appears that in all sizes of communities it would be economically favourable to go in that direction, or if you have a single tap when you are less than 50 homes; for the whole house - when you are less than 30 homes.

For reverse osmosis, and the various contaminants addressed by reverse osmosis for drinking water only it was more economical with point-of-use. For single tap, less than 90 homes, and whole house for R.O. was not considered.

From my point of view, in many areas where you are on a private well and you have a septic system and you are contaminated, for example, with VHO, the reject water, if it's high in concentration, you have no place to put it. So you have a problem. This is one of the reasons why whole-house systems were not considered for areas of this type.

For activated alumina and the fluoride removal question, for drinking water only, again all sizes - favourite is the point-of-use for single tap less than 80 homes, and for a whole house less than 60 homes. And for mechanical filtration and activated carbon, all scenarios from a strictly cost point of view appeared to favour point-of-use.

Now a product selection! You are faced with your contamination problem. You know that some products work. You know that some products do not work. How do you, as an individual, make a selection of a product and have confidence that it will work? First of all, if it's too good to be true, if it solves all your problems, if it is a new secret proprietary process, forget it! The main point is to know the source of the product: a reputable manufacturer, a reputable dealer will have data available for your review. Check the performance, make sure that it does work, and ask for help from a professional! Performance assurance: again, you deal with a dealer who has been in business for a while, who is a member of an approved association, who knows water and water treatment. Be sure you get the data on the performance for the contaminant in question! If there are contaminants where a certification exists - be it a standard of one type or another - be sure you look for that! In Canada, we now have industry guidelines that govern the activities of dealers who are members of the Canadian Water Quality Association. And if a dealer, for example, makes claims which are over and above the performance of the product, we attempt to have them withdraw those claims and make appropriate claims and use a product appropriately. Or if that fails, the Consumer and Corporate Affairs Department is contacted and they are able to put a little teeth into compliance with these guidelines. It is very difficult for a trade association to police its members.

In looking for standards in certification: for filtration units the Water Quality Association in the States has a standard S 100-81, and the National Sanitation Foundation has two standards; one for aesthetic effects, which is Standard 42, and one for health effects, which is Standard 53. ASTM also has standards for filtration capabilities.

For anion exchange which again I am referring strictly to the contaminants in the Primary Drinking Water Regulations, the Water Quality Association has standards and the NSF has Standard 53 for health effect items.

For reverse osmosis, the Water Quality Association has just adopted a certification program. ASTM has had, for a number of years, membrane performance standards, and the NSF parts of 53 for certain units may be applicable. But that has yet to be determined. For anion exchange, there are again a number of standards available. There are some problems with certification and standards.

Acceptance by health officials: if the health official recognizes and knows the agency and reviews the standards and has acceptance, it's a very good technique for ensuring performance of a product. It is expensive to test under these standards of performance. If you test under Standard 42 or 53 of the NSF, you know it can cost in excess of 10 to 20,000 dollars which is a lot of money, and all manufacturers cannot afford that. The availability of a standard for removal of a contaminant in question: many of the contaminants are not in any of these standards. So there is no standard! And also the time response in developing standards for the removal or performance of a product is long. In development of Standard 53, it took approximately seven years! So it's not a rapid occurrence.

There is product available. I want to emphasize that you know your source again, and you check the performance of the product. You ask a professional for help. One area to go back on would be the Canadian Water Quality Association and Lou Smith, who is the executive director, will be more than happy to attempt to answer, and I think he will answer questions concerning performance of point-of-use devices.

Thank you very much!

UNEDITED TRANSCRIPTION

Additional Discussions, Questions and Answers

Dr. Andrew Benedek,
Zenon Env. Ltd.

We had three excellent talks and while I was sitting there I also had a religious experience. I was listening to Dr. Wikstrom and he showed a slide, and suddenly it hit me that it looked familiar.

About ten years ago, I have designed a UV combination activated carbon filter for a company in Sweden while I was a professor at McMaster. And I forgot all about it. I thought I wasted my time helping this company. And here is Dr. Wikstrom saying to me, I wanted to show a Canadian Unit.

Anyway, we are all set for our panel discussion. We, as I indicated, had three excellent talks and one of the chief talker has just come back. We had two very good reviews. One reviewed what their point-of-use systems are. I think it is very encouraging to hear that these systems are being systematically evaluated and there is an organization behind them. We had a good review of ozone and its applications, not only in Europe but in North America. We also had a very timely talk by Jack DeMarco on the Cincinnati system. He talked about a very important plant that has been very carefully developed and hopefully it will go into operation. Maybe, to leave this for our panel discussion, I would like Jack to do just a touch more than he has done because for those of you who haven't followed him on the lecture circuit, he used to be E.P.A.'s key man in running multi-million dollar pilot studies all across the United States which were designed to adapt some of the European technologies that Rip talked about. And perhaps, Jack, you could start our discussion by telling us what we have learnt out of these large studies.

Dr.Jack DeMarco

I'll be glad to, Andy. Perhaps, however, it might be more fair to see first if there are any questions. If there are no question, perhaps then one might entertain that. I see Steve coming to the microphone.

Dr. Andrew Benedek

What I wanted to do, Jack, is put a little perspective on the activated carbon because we didn't get the perspective that Rip did. So can you, maybe very quickly do this, and perhaps later we can go back into details. I wanted to paint the overall picture a little bit more complete than it has been done.

Dr.Jack DeMarco

We did do a number of studies with E.P.A. at different locations for granular-activated carbon. Studies were done with and without ozone, I think you are getting to the ozone question, perhaps that is what you are driving at. Most of those studies that have been accomplished with granular-activated carbon have been in industrial waterways such as ourselves, the New Orleans experience, Jackson Parish, Louisiana, New Orleans have projects ongoing similar to ourselves and it's been my understanding that New Orleans is also considering granular-activated carbon for their industrial source waters. There were some additional studies that were conducted but I don't feel comfortable speaking for my former employers, E.P.A., relative to the results because those studies were not totally complete prior to my leaving the agency. I am familiar, however, that - or at least I would address you to the fact that in our country, the United States, we did try to assess the ozone GAC issue. And you have heard from Dr. Schalekamp, you have heard from Rip. There are facilities being put in the United States, but they are no ozone/GAC facilities put in the United States at this point in time.

The results of the project in Philadelphia, Pennsylvania, are just now available, I understand. The results from a project, Ozone GAC Project in Freeport, Louisiana, indicated that there was a modest improvement with ozone GAC. But one has to be very careful when one talks about what the system will do. And I think the care has to become up front when you try and understand, how did you measure and what were your objectives in using that system? I think it is unfair to the European practices to compare them without understanding fully what they are trying to do. And I think that's extremely important to understand.

The ozone/GAC, at this point in time, I would estimate in the United States would probably need further studies, perhaps because many people are from Missouri, so to speak, in our country, where you have to prove it. We have ourselves, at Cincinnati, looked at ozone up modestly. I have just completed a three-month study looking at ozone, but not with GAC. Now to do that study carefully would take more time.

Our system that we are putting in in Cincinnati would not necessarily make it that we could not use ozone. We are not going to pre-disinfect with chlorine if we can get away with it before carbon. We will disinfect after the granular-activated carbon process for a number of reasons. Steve, you did have a question. It might be polite to perhaps address the questions from the audience rather than having any of us going on.

Steve Bonk

Thanks, Jack! A couple of questions. First of all, can I assume that you entered into this whole GAC project from the basis of the fact that Cincinnati was on a highly industrialized or chemically polluted river? Had it not been, would you have actually gotten involved in such a massive project?

Dr. Jack DeMarco

I can't answer directly for Dick Miller and the Waterworks because I was not with the utility at that point in time. It's difficult to say whether without the fanfare, without the attention, without the concern of our citizens, that we would have perhaps moved forward. That's a little bit unfair to Mr. Miller and the individuals because we had the... there is a kind of an innovative history at Cincinnati Waterworks. Rapid sand filtration was first implemented in the United States at that location. Although Louisville, Kentucky, lays claim to fame because Ford did have much of his work there and implemented it in Cincinnati. But that is the best I can answer in that respect, Steve.

Steve Bonk

Very fine! Another question. You showed some cost figures on one slide, I think indicating the added cents per 1,000 gallons of cost due to the GAC process. Roughly, what percentage increase would that involve in the total cost of water production for Cincinnati?

Dr. Jack DeMarco

Only 25 percent! Our annual operating budget is in the neighbourhood of about 39 million dollars. We talked about approximately a 10-million dollar annual operating cost increase that comes to about 25 percent.

Steve Bonk

Okay! Third question. Roughly, the total time lapse between the time of inception of your trials and the completion or the implementation of the final project in years - you are talking seven, eight years?

Dr. Jack DeMarco

Yes!

Steve Bonk

You have been at this for about four years now, I believe.

Dr. Jack DeMarco

Yes, the project was approved. Now this is with... I have to answer this two-ways. I guess one way is that if you want to do it yourself versus if you want to enter into a cooperative agreement. During that project, we received 75 percent of their 4 million dollars from the federal government just to research that project. We put up roughly 1 million dollar and that project started in the fall of 1977. That's when we started with the morass of the applications and the like. The project lasted until 1982, so roughly four and a half years of actual investigations with lead time to get the application approved. And then, say, an additional four years to implement. So, you are talking about a total of maybe eight or nine years, yes.

Steve Bonk

Okay! One final short question. What are the potential problems that exist with respect to the byproducts involved in the combustion of the carbon ________ on regeneration?

Dr. Jack DeMarco

Pardon?

Steve

... the potential problems with respect to the byproducts of combustion?

Dr. Jack DeMarco

I can see Joe Cotruvo fed you a question.

Steve

No, I haven't even been talking to him.

Dr. Jack DeMarco

Steve, when we went to City Council with our proposal, when Dick Miller asked City Council to consider approving the design function, we included in that report an indication that we still intended to try and make that as perfect a system as possible. We went beyond of what was expected. It was not in the project. E.P.A. didn't ask us to do this per se. To actually understand - in the combustion technology part, what happens when you reactivate dead carbonizide, we were quite familiar, quite confident in the adsorption phase that we were not posing any problems because most of us in one way, shape or form, to ___________ have used carbon through the years. On-site reactivation was somewhat new to us. We did have analyzed for all of the existing air pollution control regulations that are now in existence. Our Stack Commission, and at various locations in our fluid bed reactivation system, and we were in compliance with that. However, in a research vane we went a step further - the kind of that pioneer instinct that sometimes gets you into trouble. But also sometimes lays out facts that are important to have laid out.

We found that in the reactivation of granular-activated carbon, we looked at the exhausted carbon, the spent carbon, we had it extracted for dioxins, we found none. We looked at various points in the treatment train and we found a small amount of dioxin in the spent carbon. We asked U.S. E.P.A. to evaluate what this meant for us, which about a year later, we got a risk assessment evaluation from their Dioxin Group and the Dioxin Group indicated that we had probably 1/50 - if my memory serves me right - about 1/50 of the types of, or the concentrations of dioxins that are in municipal incinerators throughout the United States. They considered the risk, from their risk assessment, something in the neighbourhood of 1 - I believe - in 8 million, one event of cancer in 8 million from such a facility. I think that's the best way I can summarize what we have at this point.

Richard Tobin,
Health and Welfare

I had just a comment and a question for Dr. Wikstrom. One is, the comment is that I would certainly reinforce the important point that he has made that we really require professional advice or competent technical advice when we are looking for a device. We so often get calls from the public and from all sources saying, I want to put something on my tap to make my better. What should I put on? And, of course, that only begs the question, what is it that you are trying to remove, what is it that you are trying to do? And I think we all have an obligation collectively to try to educate the public to the fact that it has to be on a case-by-case basis.

But my question was: With regards to some cost scenarios, I feel it's quite important that any type of device in the home have some sort of assurance to the consumer that it's going to do its job over a long period of time. And if you are talking about putting these devices into every home in a community, have you costed into it the multiple testing, who is going to the testing, what is it going to cost and how does it compare with the much fewer samples, I would think, would be required to do the same testing on a municipal, collective basis?

Dr. Lee Wikstrom

Yes, Richard, we did look at the entire scenario which included - there were a number of options that were considered. For example, was there a small water company or filter district formed that would perform the activities like a water company, where they would have an individual who would monitor the devices, assure they were working properly, change filters when required, that was one of the options. Also, a circuit writer type of individual who would work for a number of small filter districts to make it more economical, where one day he would be in one community, the next day he would be in a different community. But the overall picture was looked at, the overall picture is being looked at right now by the U.S. E.P.A. in the Silverdale, Pennsylvania, Demonstration Project, where the cost of installation, the cost of the owner of the water company going to the various homes, fixing leaks, if a leak exists, or changing cartridges, whatever has to be done, you know, all the way to billing the customer for the use of the device was put into the scenario. I am not saying that those numbers are correct today because this was done a few months ago because we are in a dyamic situation. But the point is that there are situations where point-of-use is more economical. There are instances where that's the only option, also. But again, I really want to emphasize, knowing the contaminant and knowing that the device performs are the critical issues.

Daniel Green

I thank the speaker for giving a very honest talk, especially Mr. Rice, Dr. Rice, and Mr. DeMarco in pointing out the limitations of technologies to treat our water to take out chemicals. I think it is important that the public know that the technology is limited, and we cannot guarantee totally pure water at their tap, regardless of the technology we have today. And even if we do, well, there is also the offshoot problems regenerating your carbon, I think to incinerate, and the gaseous emissions. There is no free lunch. You cannot get rid of toxics by just applying something at your tab. It goes somewhere. And I think that Dr. DeMarco's presentation, dealing with the Ohio River, talking about all of a sudden peaks of benzene, which means that there has been industrial emissions. The cost of the Cincinnati project - you talked about 10 million dollars. Is that capital, ten million, initial investment or is that...?

Dr. Jack DeMarco

No, on that slide we showed the capital cost was approximately 40 million dollars. The 10 million dollars was the annual operating excess cost that we would have.

Daniel Green

One wonders what one can do at point-source emission of contaminants with 10 million dollars in the Ohio River Basin per year to prevent contamination, instead of having to spend it at the point.

Dr. Joe Cotruvo

A question for Dr. Wikstrom. If I understood some of your slides where you compared the cost of providing different quantities of water, you concluded that in the case where two gallons of water was being provided solely for drinking purposes, that that was cost-effective in every case, any-size community.

Dr.Lee Wikstrom

Correct!

Dr. Joe Cotruvo

I have serious problems with that. I don't think it's physically possible that that could be correct. If you are saying that the cost of that point-of-use would be smaller than the installation of a central treatment system and operating a central treatment system in the community, that would mean that the cost of that device would be on the order of a few dollars per year, and I think Jack's system would perform in that range, whereas the cost of a point-of-use device would probably have to be on the order of 50 to 100 dollars per year once one considers reactivation, sampling, and everything else. Am I understanding correctly?

Dr. Lee Wikstrom

A point-of-use device for drinking water, you know, for the two gallons a day only would not be of that operating cost. There would be a much smaller operating cost. It would be down under 50 dollars a year.

Dr. Joe Cotruvo

Well, certainly the cost of a central system would be well under 50 dollars per year, too, per family. So, I think our perception is that point-of-use treatment may have some applications in small community situations. But, very quickly, as one exceeds a relatively small number of homes, and I don't know where that is off-hand but it may be a few hundred, one then begins to achieve a balance of scale by going toward a central system.

Dr. Lee Wikstrom

The economics are less controversial at that point, that's exactly right! And it's more clear-cut as to a break-point. I agree wholeheartedly.

Hank Barbylan,
Georgean Technologies

One of the questions that I would have for Lee and it sides a a little bit with the question that was raised over there, and that is the fact that we are trying to treat all of our water to a drinking water standard. I would like to know what percentage of the water that is being consumed in typical communities is actually being used for drinking water. In other words, is that really essential to treat every drop of water to that high a quality?

Dr. Lee Wikstrom

Normally no! Normally... I think Jack would be better to answer the part about the percentage of water drunk versus used for other purposes. One area that I'd like to refer to is the area of benzene in a well water. There you would have to treat all of the water to eliminate the inhalation problems as well. So there are instances where you have no option but to treat all the water because of the nature of the contaminant. But in most cases, that may not be the case.

Dr. Andrew Benedek

We are just about running out of time. Rip, no one asked you a question because you answered all the questions, I gather. But you want to have the last word here?

Dr. Rip Rice

Oh, thank you, sir! I appreciate that. Anybody can leave at any time during my last word.

But I have written down several. One of the things that I did want to point out - and I think it is very important but I was unable to get to - is the "ozone" oxidation of THM's. It doesn't happen. At any reasonable rate. You have violent agitation when you put ozone into the water. Volatile THM's will irrate out. But that is not chemical oxidation with ozone. And the final point, the last word is: if you are going to pre-chlorinate, recognize that once you make those chlorinated cells and otherwise brominated organics - once you make them, you got to pay to get rid of them. And you got to pay a hell of a lot more than you would if you don't make them in the first place! And there are ultimate treatment technologies available, which we are all starting to look at. Hosanna!

DR. VICTOR KIMM

DIRECTOR, OFFICE OF DRINKING WATER
U.S. EPA

ISSUES IN WATER QUALITY FROM THE U.S. PERSPECTIVE

March 26, 1984

VICTOR J. KIMM

DIRECTOR

OFFICE OF DRINKING WATER

U.S. ENVIRONMENTAL PROTECTION AGENCY

"ISSUES IN DRINKING WATER QUALITY"

Thank you Dick. It has been a pleasure to be with you for the last two days and watch you discuss problems related to drinking water quality which are similar to those that we have been struggling with in the United States. Today I will take a few minutes and share with you some of our experiences. I'd like to begin, though, by making it very clear that all the things I have to say reflect our experience in the States in implementing our National Safe Drinking Water Act. I know your institutional arrangements are very different and these remarks are in no way intended to imply either favorable or unfavorable comparisons between our respective ways of managing governmental programs. I believe that our experience may provide you with some added insights as you move ahead in the drinking water area in Canada.

Specifically, I would like to talk about our national drinking water legislation, our experiences in implementing this law and some of the problems we have encountered. Then I will try and draw a few conclusions and identify several problems which I suspect, you may also have to deal with.

In the United States, the federal government has maintained a long-standing interest in drinking water quality. Some of it parallels the Canadian experience. Back at the turn of the century, we also were faced with high levels of life-threatening waterborne illnesses which were largely eliminated through the application of filtration and disinfection techniques. In our country, State Health Departments played a dominant role in formulating national guidelines for drinking water quality and requiring the utilities to install changes in drinking water treatment technology.

At the end of 1974, our Congress was considering national drinking water legislation which had been under discussions for several years. The record of those hearings indicated quite clearly the uneven quality of State programs for the supervision of drinking water quality. Some States where aggressive and effective, while others had programs in very serious states of decline.

A second issue that led our Congress to action concerned the presence of trace organic contaminants in drinking water. During his presentation yesterday, Dr. Bob Harris briefly alluded to his minor contribution to the enactment of our national drinking water legislation--that is one of the great understatements of the year. Dr. Harris participated in a national television program in 1974, during which he warned of the potential dangers of organic contaminants in drinking water and described some preliminary epidemiologic studies he had conducted that suggested a link in the city of New Orleans between occurence of cancer and the presence of pollution-related contaminants in the drinkinq water. That television show received a great deal of public interest and the legislation which had been pending for a number of years was enacted by the Congress in a matter of weeks.

Legislative Framework

Simply stated, the Safe Drinking Water Act of 1974 assigned responsibility to the federal government for research, standard setting and enforcement in the case of imminent hazard situations. Implementation responsibility -- making sure that the public water supplies conduct required monitoring and comply with all applicable standards -- rests with the State governments as long as they adopt requirements no less stringent than the federal standards. Where the States have not assumed these responsibilities, EPA enforces the program directly.

Let me expand a bit on how our statute works. Under our statute public water supplies are defined as those which serve more than 25 people. At the time the legislation was passed, the expectation was that there were about 20,000 such systems in the States. In fact, through inventories conducted by the States, we have identified 60,000 public water systems, most of them small. This difference in the predicted and actual count is an indication that State programs were not uniformly effective in reaching small systems.

As I mentioned, the statute gives EPA authority to establish national standards for drinking water quality, which we call "maximum contaminant levels", that are set to protect public health taking cost and feasibility into account. With these standards the Agency must prescribe minimum monitoring frequencies. The Act also provides us with the authority to require specific treatment processes to deal with contaminants that cannot be readily measured by the utilities. In addition, the statute places the responsiblity for monitoring and compliance with the standards with the utilities.

The statute also includes a fairly unique provision, which requires utilities in the United States to provide public notification to their customers when they fail to monitor or when the drinking water quality exceeds the standards. As you might imagine this provision--public notification--was a cause of great concern to many of the utilities initially, although it has won better acceptance over time. However, the Congress believed that the most effective way of ensuring the quality of drinking water was to ensure that customers would be aware of problems. In fact, this requirement seems to be effective although it may be slightly modified in the future to distinguish between serious and minor violations.

As for implementation of the program, our Safe Drinking Water Act provides that the implementation responsiblity should be given to the States as long as they have regulations at least as stringent as the national requirements. As an incentive to participate in the program, we provide federal grants to States to help cover administrative costs. We believe that these grants have funded major improvements in the personnel and analytical capabilities of State Agencies involved. The delegation process has been very successful: 52 of the 57 States and Territories presently run the program. I believe that most of my counterparts at the State level would agree that they are effective participants and colleagues in implementing the program. However, this relationship is not without some tension and occasional disagreements.

In addition to State officials who supervise the drinking water quality programs on a day-to-day basis, our constituency includes special committees in Congress that focus on drinking water problems, our waterworks fraternity which includes both municipal and private utilities, associated consultants and the academic community interested in the subject and a fairly vocal environmental community which has from time to time expressed considerable interest in the actions or inactions of EPA. As a practical matter, we devote considerable attention to keeping all of these groups informed about our activities.

Program History

If one looks back to the beginning of the program, the period from '75 to '77, the States generally looked at the enactment of a drinking water program with some apprehension. But basically, federal grant money enabled them to significantly upgrade their institutions which was generally viewed as constructive. From the water utilities we faced much more skepticism. The American Water Works Association supported enactment of the legislation, but many of its members were quite concerned that this new EPA program would get carried away and become disruptive. The environmental community, since they had been active in getting the legislation passed, felt a certain proprietary right in setting our priorities and nudging us along to move more quickly. In fact, the first litigation we faced was brought by an environmental group because they felt we were not moving quickly on new standards. However, all things considered, the first couple of years of the program proceeded fairly smoothly as we promulgated interim national drinking water standards and helped the States upgrade their programs to qualify for delegation of implementation responsibility.

Our first major problems surfaced in the 1978/79 time frame when we moved aggressively to control organic contaminants by proposing numerical standards for trihalomethanes and a requirement that large systems fed by polluted surface water install granular-activated carbon as part of their treatment systems. This led to a major confrontation with the waterworks community. The utilities perceived our actions as a direct attack on their institutions and as a costly and unnecessary intrusion into their world. An organization called "The coalition on Safe Drinking Water," was created to oppose these proposed regulations and collect a war chest to sue EPA if we promulgated regulations they did not agree with. As one of my friends in the utility world said to me, EPA's action was the best thing since typhoid to get the water utilities of the United States interested in the standard setting process. This effort led to a very confrontational public comment period after which EPA decided to promulgate the THM standard and postpone action on the GAC requirement for a variety of technical and political reasons.

During the last two years when EPA was not actively pressing additional standards we have tried to shore up our links with all our constituency. In preparation for the next generation of standards, we have conducted several rounds of national workshops during which literally hundreds of utility managers, State officials, and representatives of the environmental and academic communities have grappled with many of the underlying problems associated with setting the standards. And while I am sure we will not all agree on positions EPA takes, I believe we have laid the basis for a more rational dialogue in the future as we propose revised drinking water standards.

We have also experienced some difficulties in establishing a working relationship with the remainder of our constituency. In terms of our links with Congress, we have seen dramatic shifts over a very short period of time which perhaps parallel your experience in Canada. In the 1981/82 time frame many believed that the public in the United States was no longer interested in aggressive protection of the environment. This led to a round of discussions of our authorities looking for ways to limit standard setting and increase the legal hurdles the Agency needed to clear before promulgating additional standards.

Last year, the pendulum swang in the opposite direction as the membership of key Congressional committees changed. Congressman Dennis Eckardt from Ohio, one of the new members, introduced an aggressive bill which would set fairly tight time frames for promulgating additional standards and provide the Agency with more effective enforcement tools to reduce non-compliance by utilities. Congressman Eckardt is particularly concerned that we have not been aggressive enough in dealing with toxic and hazardous wastes that may be finding their way into underground sources of drinking water. The current session of Congress has yet to act, but I am expecting that the thrust of future reauthorizing legislation will be far more aggressive than anything that I would have conceived of as possible as little as a year ago and reflect continued high levels of citizen interest in public health protection.

One of our major institutional relationships is our federal/state interface. We at the federal level talk about partnership while some of the states talk about being junior members of the firm. This relationship inevitably includes a great deal of tension. At the national level we are interested in compliance rates with uniform national standards while the States are trying to tailor national requirements to the specifics of the problems they face. Again, when we have been able to provide States with effective technical assistance, to be responsive to their problems, and to include them in formulating policies, the relationship works well. But, where the States have seen us as burdensome, bungling bureaucrats, engaged in meaningless bean counting, communications break down and we encounter serious problems.

General Observations

To sum up, in the United States we adopted a federal role focused primarily on research and the development of national standards. It has been our experience that there is not a significant resource base at the State level with which to conduct these activities. I think that standard setting with full public debate will continue to be one of our most important national functions. Program administration on the other hand seems best managed at the State level.

The second major problem that we have encountered deals with small systems. In the United States, we have a high percentage of our total number of systems that are small systems and most of those are trailer parks. Trailer park owners do not think of themselves as public water system managers nor do they have the capability to run complex treatment plants for their water supplies. It is my belief that our basic legal structure which requires us to set national standards based on feasibility for large systems using reasonably good sources of water backed by federal enforcement, is the proper way to protect public health. However, some kind of administrative variance mechanism is also needed where the health risks are not serious and compliance is truly infeasible to deal with non-compliant small systems. Our legislation includes such provisions and we are trying to use variances and exemptions to require compliance where feasible and ensure a realistic assessment of available alternatives. Lacking federal grants for the construction of drinking water facilities, many of our States have created grant and loan programs to help small systems. These actions provide better water for many people, but do not eliminate the problem altogether.

Finally, we have a problem with public confidence. Dr. Shannon's talk yesterday seemed to describe precisely some of the problems EPA is currently facing. If I may try to paraphrase her remarks, I think she said that public reaction is likely to be very strong, protective and sustained if the public perceives the problem as involving: (1) a situation in which the magnitude of the involuntary risk to the public is potentially serious; (2) a situation where good scientists cannot agree on the seriousness of the threat: (3) a situation where remedies are complex and expensive and timely to implement; and (4) a situation where the public perceives the responsible authorities as defensive and, uncertain about what should be done. This unfortunately, seems to be a very precise description of how many people believe we are dealing with ground-water contamination problems in the United States, especially related to the control of hazardous waste sites.

It seems to me that the only response to this challenge is for public health officials to become much more forthcoming in dealing with these problems. We in the public health community must find ways to begin to talk in public forums about the risk to health associated with ground-water contamination and what can reasonably be done to reduce human exposure to potentially harmful contaminants in drinking water. There are many words like "acceptable levels of risk" which are seen by the environmentalists in the United States as code words synonymous with inaction. I don't think that anybody believes that inaction is an acceptable public policy in the current set of circumstances.

For our part we at EPA we are trying to open up the process by which we assess risk and move to control exposure through public dialogue and interchange with the independent scientific community. It is the Agency's policy under Bill Ruckelshaus leadership that we move to be protective of public health even in the face of scientific uncertainty.

Again I cannot tell you how much I have enjoyed the last couple of days. I hope that these remarks about our experience in the States can be of some help to you in dealing with problems that I presume have similarities to your situation in Canada. Once again I want to thank you for inviting me to participate in this program.

MR. DOUGLAS G. EDWARD

PRESIDENT
CANADIAN ENVIRONMENTAL LAW ASSOCIATION

A PROPOSED LEGAL FRAMEWORK FOR THE REGULATION OF DRINKING WATER

PREFACE

This paper draws very heavily on research materials and briefs produced by the Pollution Probe Foundation, Toronto, Ontario, and the Canadian Environmental Law Association, Toronto, Ontario.

Due to the limited time available for the presentation of this topic, this paper necessarily avoids descending into detail on the majority of the issues presented. For further information, please contact one of these two organizations.

For further reading, the following two publications provided the bulk of the source material for this paper:

1. Water Fit to Drink? The Need for a Safe Drinking Water Act in Canada (1982), 11 C.E.L.R. 80, Toby Vigod (Counsel, Canadian Environmental Law Association, and Associate Editor, Canadian Environmental Law Research Foundation), and Anne Wordsworth (Researcher, Pollution Probe and Director, Canadian Environmental Law Association);

2. Drinking Water: Make it Safe (1983), Brief prepared by the Pollution Probe Foundation.

A PROPOSED LEGAL FRAMEWORK FOR THE REGULATION OF DRINKING WATER

I. INTRODUCTION

By the time this paper is delivered, everyone in attendance at this conference will have become quite well acquainted with the scientific and medical imperatives which indicate the necessity for the rapid development and application of technological skills in relation to the treatment and monitoring of drinking water supplies. In this presentation, I intend to make the argument for the concomitant development of a legal framework to insure that the very highest levels of these skills are brought to light and put to work in insuring the adequacy of our drinking water supplies, and insuring that the public has the broadest possible knowledge in relation to the issue and the greatest possible opportunity to participate in the regulation making process which will set the standards for the water that the members of our public must drink every day to survive.

Through the ages, metaphor after expression after cliché has been handed down from generation to generation in confirmation of the critical role that drinking water supplies play in our survival. It is most distressing that in Canada, a country blessed with twenty-five percent of the entire supply of fresh water on this planet, a country that has more fresh water lakes than the rest of the world put together, expressions such as "as crystal clear as water from an underground spring" and "as pure as the driven snow" simply do not apply in today's world and harken back to a time long past. Unless significant steps are taken to protect our fresh water heritage, we run a serious risk of joining the ancient mariner in the lament "Water, water, everywhere, nor any drop to drink."

The overwhelming damage to our fresh water heritage has been done since the second world war. When I lived in Kingston, Ontario, from 1970 until 1973, I used to take my skates to a seventy-eight year old gentleman for sharpening. Besides having invented his own skate-sharpenning machine, and doing the very best job of sharpening skates I have ever encountered, the fellow was a muskellunge fisherman. We used to talk alot about the multitude of lakes and the natural beauty of the countryside in the Kingston area, and he told me that he was glad that he would not be around very much longer to see what we were doing to it. He recounted that, at the end of the second world war, when he went out fishing for musky on the St. Lawrence River, he could see down thirty feet, and sometimes more, into the water. By the mid to late 1950's, he could only see down into the water twelve to fifteen feet. By the late 1960's, he could hardly see the bottom edge of the blade of his paddle, some two feet deep into the water.

The industrial explosion after the second world war led to the manufacture, use, waste and disposal of a multitude of chemicals. Due, in many cases to ignorance, and in others to carelessness, and in others to downright negligence or greed, many of the chemicals so produced were used or disposed of in a manner that allowed them to get into our air and surface and ground water systems. Our driven snow, the source of much of our surface and ground water, is no longer pure, but suffers from a plague of dissolved chemicals and, particularly, a very high level of acidity. Contaminants enter our surface waters from direct discharges, agricultural and urban run-off, and airborne fallout. Ground water supplies have been affected by inadequate or improperly designed waste disposal sites, and chemicals that are not removed despite the significant natural filtration carried out as the waters percolate through the soils.

A major problem has been posed by the production of synthetic organic chemicals, many of which are among the most toxic substances known to human beings. For these, and other chemical contaminants, we do not have currently in place water treatment systems or technology to eliminate, completely or to a certain standard, those chemicals from our drinking water. In addition, chlorination of water supplies, developed in the 1920's for the purpose of eliminating bacteria implicated in serious diseases, compounds the chemical problem by synergistically combining with a naturally-occuring substance or other chemicals in the water supply, producing still another class of hazardous substances known as trihalomethanes.

As more and more chemicals in our drinking water are identified and as we become aware of more and more chemical dumps containing extremely toxic substances, which dumps are feeding their deadly leachates into our surface and ground water supply, the question subtending this entire area has changed from whether something should be done to what should be done and how fast can it be done. The remainder of this paper will analyze that question from a legal perspective.

II. THE EXISTING FRAMEWORK - PROBLEMS

(1) Jurisdiction

Our basic constitutional, The British North America Act, was legislation that intended to reflect sound government organization in another era, when pollution was, at the very worst, extremely localized with little impact. As a result, the division of legislative power did not reflect consideration of environment or environmental legislation as a discreet subject matter. The treatment of environmental issues, therefore, must occur within the rubric of a distribution of power based on categories and definitions, such as peace, order and good government or property and civil rights, which often bear little or no logical connection with environment as a jurisdictional area, and often lead to a perversion of processes of thought and logic in attempting to slot legislative initiatives within one of the jurisidictional areas described in 1867.

These difficulties have lead to a perceived overlapping of jurisdiction between the Federal and Provincial Governments, and, due to the lack of a clear mandate for legislation in relation to environmental issues on the part of either level of government, confusion, at the very least, and abdication of responsibility, at the very worst, has been injected into our legislative attempts to deal with environmental problems. Added to this difficulty has been the natural, at one time in our history, allocation of the responsibility for the production of potable water supplies to the municipalities. In recent years, beginning in the mid 1950's, the provinces have taken a stronger and more pervasive role in regulating water supplies.

(2) Approaches

Legislative attempts to preserve quality water supplies have focused on the prevention of pollution of the water supply. In spite of the flood of environmental legislation dealing with pollution control and abatement during the late 1960's and early to mid 1970's, we still suffer from gaps in regulation and significant failures to enforce existing legislation addressing the manufacture, use and disposal of contaminants. In particular, serious difficulties exist in providing a framework for the rehabilitation or clean-up of dump sites that have existed from times when conventional wisdom identified no difficulties with the dumping of waste chemicals into land fill sites.

In spite of the fact that the legal framework has not been able to deal with the pollution of water supplies so as to ensure the potability thereof, there is no enforceable legislation aimed at ensuring the quality of water supplies at the point of consumption. The following is a brief summary of the Federal and Ontario legislation dealing with the preservation of quality drinking water supplies more or less indirectly.

III. FEDERAL LEGISLATION

(1) Fisheries Act

The Fisheries Act was designed to carry out the conservation of fisheries within the jurisdiction of the Federal Givernment. As part of that effort, the Act prohibited the deposit of deleterious substances into water frequented by fish. Although this legislation has teeth, and has been proven effective in a number of prosecutions, the implementation and enforcement of the Act has, almost exclusively, been left in the hands of the provinces. Because the Province of Ontario views the enforcement of its environmental legislation, particularly The Ontario Water Resources Act and The Environmental Protection Act as more important, and for various other reasons, the Fisheries Act has only been exercised on one occasion by the Province of Ontario. As a result, in the current state of affairs, the Act has relatively little impact on the preservation of drinking water supplies.

(2) Canada Water Act

The Canada Water Act was envisioned as creating a framework for the comprehensive management of water resources by region, with the co-operation of the provincial governments. Once a region has been designated as a water quality management area, the deposit of waste of any type in its waters or in any place where waste may ultimately enter those waters becomes an offence.

In Ontario, no water quality management area has ever been established under the legislation.

Part III of the Act, and regulations passed thereunder, is the only portion of the Act that provides for direct enforcement powers. The phosphorous concentration control regulation passed pursuant to this part has been effective in controlling the growth of algae in our water systems by limiting the phophorous content in laundry detergents.

(3) Canada Shipping Act

This Act has utility in permitting cabinet to make regulations in relation to marine activity that could give rise to pollution from ships, and has important application in protecting drinking water supplies from marine accidents or spills. In terms of our problems arising out of the fracturing of jurisdictions, it should be noted that this Act is administered by The Department of Transport, not The Department of the Environment.

(4) Federal Guidelines for Canadian Drinking Water Quality (1978)

As stated previously, there is no legislation that specifically addresses drinking water quality. Health and Welfare Canada promulgated, in 1978, non-enforceable guidelines which were developed by the Federal-Provincial Working Group on Drinking Water.

In spite of the laudable objectives of the guidelines, which recognized that "water for drinking, culinary and other domestic uses should be safe, palatable and aesthetically appealing", and "water should be free from pathogenic organisms, hazardous chemical and radioactive substances, and objectionable colour, odour and taste", the guidelines address only forty-two substances out of a total of three hundred and eighty-one chemicals identified by The International Joint Commission as having potentially adverse health effects. In addition, synergistic effects of chemicals combining in the water supply are not taken into account in evaluating toxicity. The guidelines deal primarily with the identification of biological and physical problems in drinking water, such as taste, odour or bacterialogical problems, and not all of the guidelines are intended to protect human health.

A major gap in the guidelines occurs with respect to organic chemicals, in that only a limited number of organics have been made the subject of a suggested limit. Further, the guidelines are not legally enforceable standards, and no-one has a legal right, therefore, to bring an action based on a violation of the maximum allowable levels contained in the guidelines. Although the guidelines provide that violation thereof constitutes grounds for the rejection of the water supply, such a provision is useless where there is no legal right of action.

There is no onus on the water supplier to notify the public when a guideline has been violated and no clear instruction as to the course of action that should be followed when violation occurs. At best, the current guidelines would be part only of a comprehensive set of regulations, with legal enforcement provisions, in legislation in relation to safe drinking water.

IV. ONTARIO

The two central pieces of legislation in Ontario that speak to water supply quality deal with point of pollution issues, and are The Ontario Water Resources Act and The Environmental Protection Act. Neither provide legally enforceable standards for drinking water. The Ministry of the Environment relies on, once again, non-enforceable guidelines outlined in "The Blue Book".

(1) Ontario Water Resources Act

This legislation was passed, initially, in the mid 1950's when it became apparent that significant pollution of natural waters was well underway. Under the Act, the Minister of the Environment is given supervision of all surface and ground waters in the Province. The Act creates an offence for a municipality or person to discharge or deposit, or cause or permit the discharge or deposit of, polluting material into or in any place that may impair water quality. There are no specific legally defined limits that automatically constitute an offence, and, because impairment is a relative concept, the potential effectiveness of the Act is limited.

Under section 44(1)(h), the Minister may make regulations "specifying standards of quality for potable and other water supplies, sewage, and industrial waste effluents, receiving streams and water courses". Although this provision might permit the commencement of a comprehensive regime of regulation of drinking water supplies, it certainly would not go far enough, and would require substantial amendment in order to provide the level of control porposed herein. Further, Ontario has shown no inclination to date to exercise this provision, and no such enforceable regulations have even been promulgated.

(2) Environmental Protection Act

This legislation was passed in the early 1970's to provide, broadly, for the protection and conservation of the natural environment, which it defined to include the air, land and water of Ontario. The Act contains an offence provision which prohibits the discharge of contaminants into the natural environment. However, there are no specific legally defined limits that automatically constitute an offence for the impairment of water quality, and the Act, therefore, suffers in the same way as The Ontario Water Resources Act.

(3) The Blue Book

The Blue Book outlines The Ministry of the Environment's water management programme, including goals, policies, objectives and implementation procedures. The programme contains four components - surface water quality management, surface water quantity management, ground water quality management, and ground water quantity management.

The goal of the surface water quality management programme is to ensure that Ontario's surface waters are of a quality which is satisfactory to aquatic life and recreation, assuming that achievement of this objective will also render water suitable for most other beneficial uses, such as drinking water.

Limits are set forth for certain substances and generally follow the Federal Drinking Water Guidelines. However, similar problems to those described in relation to the Federal guidelines exist. Limits are unenforceable, and are set for less than thirty substances. Many critical chemical contaminants, especially in the field of organics, are not dealt with at all. Again, The Blue Book is of limited utility in ensuring safe drinking water.

(4) Objectives for the Control of Industrial Wastes Discharge in Ontario, 1976.

Again, these constitute non-enforceable objectives, setting forth desirable concentrations of contaminants. For this reason, these objectives are of extremely limited utility in ensuring safe drinking water supplies.

V. SAFE DRINKING WATER ACT - A PROPOSAL

(1) Jurisdiction

Although the provision of adequate supplies of drinking water has traditionally been viewed as being a matter of local concern, and has been largely left to the municipalities with, in recent years, increasing provincial involvement from the point of view of pollution control, there is a good case for Federal Government involvement. The protection of drinking water supplies is obviously of interest to all Canadians, and interference with those supplies does not pay attention to provincial boundaries. Although treatment and consumption occur on a localized basis, the methods of treatment are dependent upon the content of the waters, which is dependent upon extremely broad trans-provincial boundary influences. Furthermore, despite localized consumption, the freedom and frequency of movement of Canadians across the country renders the provision of safe drinking water supplies a matter of national interest and concern.

The Federal Government's power to legislate for the peace, order and good government of Canada, and the criminal law power, could provide bases for enactment of legislation at the Federal level. Indeed, The Environmental Contaminants Act exercised these heads of federal legislative power, and indicates the legitimacy of the jurisdiction to enact a safe drinking water act.

As noted previously, the provinces would also have jurisdiction in this field, in an overlapping manner, due to the property and civil rights head of power and local works and undertakings. It is remotely possible that the matters of a local or private nature head of power might be exercised, although this head of power seems unavailable if one assumes that the problem has national dimensions which are more significant than the local dimensions.

For the sake of national uniformity, it would be preferable to have the legislation enacted at the federal level. However, it must be recognized that provincial co-operation is critical, because provincial tax dollars will be spent in producing the treatment facilities that will be required to deal with standards in some areas. It may be the case that the legislation would have to be enacted at the federal level, with the provinces having an option to make their standards more stringent, The goal of the surface water quality management programme is to ensure that Ontario's surface waters are of a quality which is satisfactory to aquatic life and recreation, assuming that achievement of this objective will also render water suitable for most other beneficial uses, such as drinking water.

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(2) Safe Drinking Water Act - Overview

As has often been the case, we are not without legislative experience in this area, albeit that experience comes from American legislation, *The United States Safe Drinking Water Act, 1974*. That Act was examined in the development of these proposals.

The following principles would be given effect to in proposed legislation:

Health and Welfare or

(1) The Department of the Environment would be required to establish regulations limiting the amounts of certain contaminants in drinking water;

(2) Enactment of the regulations would be manadatory within a certain time period, but would be subject to a period within which members of the public would have the opportunity for input into the regulation making process;

(3) Two different sets of water quality regulations would be enacted, Primary Drinking Water Regulations - setting maximum contaminant levels with a view to adverse affects on human health, and Secondary Regulations - dealing with levels of substances adversely affecting odour, appearance, or visability of drinking water;

(4) The two sets of regulations would apply to both public and private drinking water supplies and to both surface water and ground water sources; and enforcement procedures and monitoring requirements would vary, dependent upon whether the source was public or private;

(5) Public and Private would be defined, based on the number of users of the source;

(6) The main responsibility for the enforcement of the Act would lie with the provinces, who would be required to pass a Provincial Safe Drinking Water Act adopting regulations at least as stringent as the Federal Act, and the Federal Government would share in the financing of the enforcement;

(7) Public water suppliers would be required to periodically sample and test drinking water, as well as to keep records and provide access to such information by the public;

(8) Members of the public would be given standing to bring civil actions against anyone for damages arising from a breach of the regulations, and for judicial review with respect to an alleged failure of the Minister of the Environment to enforce non-discretionary provisions of the Act or any action purportedly taken under the Act;

(9) Members of the Public would have the right to launch private prosecutions for alleged offences committed under the Act;

(10) The Act would require public water suppliers to notify customers and the general public when the system was not performing properly or adequately, and to provide alternative sources of supply when necessary;

(11) Mandatory research into certain critical water quality problems would be provided for.

(3) Safe Drinking Water Act - Detailed Provisions

The following material has been reproduced, word for word, from (1982), 11 C.E.L.R., 80, at page 89, and outlines in more detail the principles which should be incorporated into the Federal and Provincial

Safe Drinking Water Acts.

(a) Purpose

The Act should state that its purpose is the protection and enhancement of drinking water quality in all areas of Canada.

(b) Definition Section

The Act should provide for the definition of relevant terminology used throughout the remainder of the Act: 'primary drinking water regulations', 'secondary drinking water regulations', 'public water system', 'private water system', 'maximum contaminant level', 'contaminant', etc. The most important definitions are listed below.

(i) Primary Drinking Water Regulations

These regulations should specify maximum contaminant levels of certain substances allowed in drinking water which may have adverse effects on human health.

(ii) Secondary Drinking Water Regulations

These regulations should include standards for substances that cause problems with the odour, appearance or usability of drinking water.

(iii) Public Water System

A public water system could be defined as one that provides piped water for human consumption and that has at least 15 service connections or regularly serves at least 25 individuals.

(iv) Private Water System

A private water system would be any water system that has fewer than fifteen service connections or regularly serves fewer than twenty-five individuals.

(v) Maximum Contaminant Levels

These should be the maximum permissable levels set for contaminants in drinking water.

(vi) Contaminants

These should include any physical, chemical, biological, or radiological substance or matter in water.

(c) Public Notification

The purpose of notification is to educate the public as to the extent to which public water systems are performing adequately. Notification must be given by public water system operators when:

(i) there is a violation of an applicable maximum contaminant level (MCL) under the national primary drinking water regulations; or,

(ii) there is a failure to perform any required monitoring.

Notification of any violation should be published in local newspapers and advertised in other appropriate media as well as included in customers' water bills. There should be a section providing for a fine for failure to comply with the notice requirements under the Act. There should also be a requirement to provide an alternate water supply where necessary.

(d) The Regulation Making Process

The federal Safe Drinking Water Act should provide for public participation in the regulation-making process. While statutory opportunities for public input into environmental regulation making are limited, there has been some sporadic movement to greater public input.

The federal Safe Drinking Water Act should make it manadatory that the Minister of the Environment publish draft national primary drinking water regulations in the Canada Gazette by a specified date (i.e. 180 days) after the coming into force of the Act. There should then be a period of 90 days for public comment on the adequacy of the proposed regulations. During this 90-day period, any person should be allowed to file a Notice of Objection and require a hearing on one or more of the draft regulations. The hearing should be before a Board of Review to be provided for under the Act.

Finally, there should be a provision that the final regulations should take effect within a specific period of time after the coming into force of the Act. (e.g. fifteen months)

The federal Safe Drinking Water Act should provide for secondary drinking water regulations to be published in draft form within 240 days after the coming into force of the Act. There should be a 90-day period for written public comment on these draft regulations and a further amount of time before which the final regulations are to be promulgated.

There should be a provision that both sets of regulations can be amended from time to time to add new parameters or to change existing standards. The amended regulations should also be required to be published in draft form in the Canada Gazette with the same provisions applying for public comment and final promulgation as the initial set of regulations.

The provincial Acts should provide for the adoption of regulations at least as stringent as the federal regulations. If a province wishes to adopt more stringent, or additional drinking water regulations, a similar notice, comment, and hearing process to the federal Act should be provided for.

(e) Federal-Provincial Cost-Sharing Arrangements and Enforcement

The federal Act should provide that a Province will have primary responsibility for enforcing the primary and secondary drinking water regulations as soon as it enacts legislation incorporating regulations at least as stringent as the federal regulations. At such time, the Federal government shall enter into a financial cost-sharing arrangement with the province to provide for enforcement capability.

f) Record Keeping - Access to Information

The federal and provincial Acts should provide that the public uppliers of drinking water should establish and maintain records, conduct ngoing monitoring programs of their drinking water sources and provide omprehensive information to the Minister of the Environment and the ublic as required under the Act.

g) Research

The Safe Drinking Water Acts should include provisions which enable ne Minister of the Environment to conduct research into the causes, iagnosis, treatment, control and prevention of diseases resulting directly r indirectly from contaminants in drinking water. The Act should also rovide for specific mandatory studies. For example, there should be a ndatory study to document the quality, quantity, and availability of ural water supplies. Another study should include research into the ources of surface and ground water contamination.

The Safe Drinking Water Act should also include provisions which ndate the Department/Ministry of the Environment to conduct research nto methods of treating drinking water that would reduce or eliminate ne presence of organic chemicals from the finished water.

n) Private vs. Public Water Systems (Offences)

While both the primary and secondary drinking water regulations ould apply to both public and private drinking water supplies, due to ne economic unfeasibility of a duty to monitor individual wells, the onitoring and notification sections would only apply to public water ystems. However, there should be a general provision establishing an ffence and penalty for anyone who contaminates a private drinking water upply. Public suppliers would also be subject to fines for violation f the drinking water regulations. Finally, there should be a mandatory provision requiring the Department/Ministry of the Environment to test for the parameters listed in the regulations at the request of any person obtaining water from a private well.

(i) Citizen Actions and Judicial Review

Both the federal and provincial Safe Drinking Water Acts should provide for 'any person' to have standing to commence civil action against any party for damages caused by a breach of the Act. There could be a requirement that the plaintiff give notice to the alleged violator prior to launching of the civil action. The Act should also allow for judicial review of any action taken under the Act and provide standing for any person to bring an application for judicial review against the Minister of the Environment, where he has failed to perform a non-discretionary duty prescribed by the Act.

(j) National Drinking Water Advisory Council

The federal Act should provide for a National Drinking Water Advisory Council to advise the Minister of the Environment on matters relating to his responsibility under the Act. The Council (approximately 15 members) should be appointed by the Cabinet for a term of office. The appointees should be non-governmental individuals with a concern and interest in protecting water quality. For example, this Council would identify public concerns, suggest areas of research, and oversee administration of the Act.

VI. CONCLUSIONS AND RECOMMENDATIONS

As was stated at the outset, there is no lack of evidence to the effect that our drinking water source supplies have been seriously contaminated. There is also no lack of evidence that many of the contaminants cannot be removed by conventional treatment processes, and may well create serious health problems now and in the future. There can be no argument that safe drinking water is critical to our survival.

The proposal for a safe drinking water act is not intended to deflect attention from pollution abatement and control. Prohibition of point of source pollution is extremely important for the integrity of drinking water supplies as well as for other reasons.

However, because clean-up of existing sites and enforcement of prohibitions against further injection of contaminants into our air and water is a massive, ongoing problem, it is necessary to control the quality of drinking water at point of consumption. The implementation of drinking water standards which can be legally enforced by the public, and a notification system to permit the public to know when the system is not working as it should, are mandatory features of the safe drinking water act. Constant monitoring and mandatory research are necessary to advance our capability to identify and treat potential problems with our water supply.

The overwhelming importance of drinking water to our health as individuals and a nation dictates that these principles be promulgated in effective legislation without delay.

DR. E. SOMERS

DIRECTOR GENERAL
ENVIRONMENTAL HEALTH DIRECTORATE
HEALTH PROTECTION BRANCH
HEALTH AND WELFARE CANADA

THE RISK FROM DRINKING WATER

National Conference on Critical Issues in Drinking Water Quality
Ottawa, 7 February 1984

THE RISK FROM DRINKING WATER

E. Somers
Environmental Health Directorate
Health Protection Branch
Health and Welfare Canada
OTTAWA, K1A 0L2

We have already learned of the wide range of hazards to which drinking water is prey. Regulation whether embodied in legislation or even in the form of suggested guidelines implicitly means that a level of risk is set. By risk we mean the probability of the occurrence of a hazard. In a statistical sense the situation could arise that the level of risk is indistinguishable from the background: the 'noise' is just too great. Lifetime excess risks greater than 10^{-7} can be considered within this category: the chance of being accidentally killed by lightning, for example. What would be the increased lifetime risk of lung cancer if 25 million Canadians smoked one cigarette a year? The answer is possible from statistical extrapolation but in a pragmatic sense it would be nonsense. In reality, we are entering the region termed 'trans-scientific' by Weinberg(1) where questions of fact can be stated in the language of science but not answered by science.

Clearly then although the public may want 'zero risk' as Dr. Kristin Shannon told us yesterday it is a chimera, an idle fancy, and we do a disservice to our masters if we pander to this illusion. The day has past when father figures from the medical and health establishment can assure absolute safety. What we have to do is to lay bare as best we can the scientific evidence for our regulatory decisions.

If one looks at the major health risks faced by Canadians - smoking, alcohol, automobile accidents - it is clear that logic and rationality can help us only so far in the path of regulation and control. The answer, of course, is that life is too complex to be reduced to simplistic, one-dimensional, probability calculations. Nevertheless it is important to understand the way in which risk analysis can be used to aid political judgements. Yesterday, Mr. Seaborn emphasized that a full understanding of the risk assessment process was the key to future policy decisions for drinking water quality. Knowledge of the transformation of the scientific estimation of risk into the final political decision illuminates all the weighing and evaluating factors that are involved.

A schematic approach to the risk assessment process has recently been developed by a WHO Working Group who met at Ulmin late 1983(2). The connecting stages between identification, estimation, socio-economic evaluation, and finally management are shown (Fig. 1) with the concomitant pressure of motivating forces. Epidemiology is certainly the most direct way to obtain evidence of the effect of drinking water on human health, however, the majority of the studies have been descriptive, or ecological, rather than analytical - whether prospective cohort or retrospective case-control. Nevertheless a review of these studies(3) does suggest a positive association between trihalomethane concentrations in water and cancer rates although the association may not stem from a causal relationship. In Canada, descriptive epidemiology has shown no differences in cancer mortality between inhabitants of fluoridated and non-fluoridated municipalities representing some 58 per cent of the Canadian population(4). More recent studies, as yet not fully analyzed by my colleague Dr. D. Wigle, are evaluating the effects of trihalomethanes, asbestos, and surface versus underground waters for some 30 low-mobility Canadian cities.

In reality most of our toxicological forecasting comes from animal, usually rodent, experimentation. Biostatistical modelling techniques enable extrapolations to be made, with varying levels of confidence, to human populations. Such techniques have been used by the U.S. Environmental Protection Agency for their water criteria documents(5). The linearized multi-stage model was adapted as a prudent conservative approach and calculations of the incremental increase of cancer risk over a lifetime estimated at 10^{-5} to 10^{-7}. The 1978 Guidelines for Canadian Drinking Water Quality(6), used similar statistical techniques to estimate that the maximum risk of cancer to a 70 kg man ingesting 2 litres of water containing chloroform at the maximum acceptable concentration of 350 µg/L would be 1 in 2.5 million per year. The risk for the detergent builder nitrilotriacetic acid at its maximum acceptable concentration of 50 µg/L would be 1 cancer in 5 million per year. In reality these risks are not measurable.

What level of risk should society set, and accept, for drinking water quality? Clearly no simple single answer can be given. Even in the U.S.A. that sets such store on tightly-worded legal formulations the lifetime cancer risks accepted by different regulatory agencies can vary from 10^{-2} to 10^{-7} (7).

Comparisons of risk estimates for widely disparate activities are ultimately fallacious as a guide to public policy. In particular those that show the risks of nuclear energy as miniscule as compared to such hazards as air-travel or smoking(8) have done little to convince a critical public.

The 'single molecule' hypothesis on carcinogenesis that was raised by Dr. Hall yesterday also leads us into difficulties when we remember that the human body already contains billions of molecules of such known human carcinogens as arsenic and chromium(9). Clearly other factors are at work including detoxication, repair, and excretion.

You will note in Fig. 1 the separation of the scientific estimation of risk from the political determination of its acceptability. Many imposing bodies including committees of the U.K. Royal Society and the U.S. National Research Council have made similar recommendations. The point is worth emphasizing but, as with many issues in life, the distinction is not always clear. Value judgements can enter the scientific assessment too for there is a subjective aspect to science.

Some countries, for example the U.K. and Sweden, already have administrative procedures whereby the scientific assessment is separated from the socio- economic evaluation in a formal manner. In occupational health, for example, parties representing industry, workers, as well as independents review the scientific evidence then reach a consensual decision. Those who must suffer the consequences of the risk, i.e. workers or consumers, are represented. These procedures may be worthy of emulation in Canada.

Full understanding by the public of the level of risks from drinking water is an essential component of the process as well as the knowledge of the hierarchy of risks. Such perception is evident in Mr. Justice Nunn's decision in the Nova Scotia Herbicide Case. The judge underlined that the level of exposure determined the hazard, that everyday products can all pose some risk but that the risk from dioxin, in Nova Scotia, if there is a risk is infinitessimally small. The judgement put the risk in context. That is how we must use science. Public perception, driven by hidden agendas, will change but slowly. The scientific basis of evidence must be used to catalyse, drive and mold public policy - but it will never be the sole determinant.

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(4) Department of Health and Welfare. Fluoridation and Cancer, 77-EHD-18, Ottawa (1977).

(5) Environmental Protection Agency Federal Register, 45, 79318-79379, 28 November 1980.

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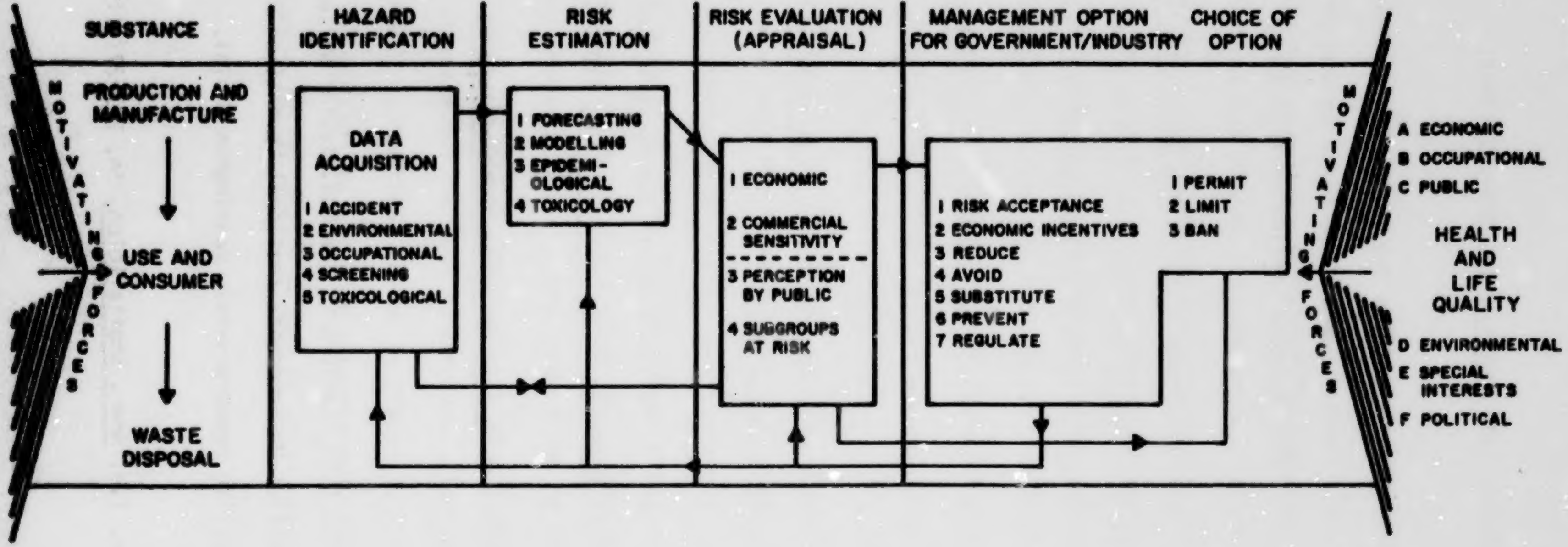
Figure 1

RISK ASSESSMENT PROCESS


SUBSTANCE
HAZARD IDENTIFICATION
RISK ESTIMATION
RISK EVALUATION (APPRAISAL)
MANAGEMENT OPTION FOR GOVERNMENT/INDUSTRY
CHOICE OF OPTION
MOTIVATING FORCES
PRODUCTION AND MANUFACTURE
USE AND CONSUMER
WASTE DISPOSAL
DATA ACQUISITION
1 ACCIDENT
2 ENVIRONMENTAL
3 OCCUPATIONAL
4 SCREENING
5 TOXICOLOGICAL
1 FORECASTING
2 MODELLING
3 EPIDEMI-OLOGICAL
4 TOXICOLOGY
1 ECONOMIC
2 COMMERCIAL SENSITIVITY
3 PERCEPTION BY PUBLIC
4 SUBGROUPS AT RISK
1 RISK ACCEPTANCE
2 ECONOMIC INCENTIVES
3 REDUCE
4 AVOID
5 SUBSTITUTE
6 PREVENT
7 REGULATE
1 PERMIT
2 LIMIT
3 BAN
MOTIVATING FORCES
A ECONOMIC
B OCCUPATIONAL
C PUBLIC
HEALTH AND LIFE QUALITY
D ENVIRONMENTAL
E SPECIAL INTERESTS
F POLITICAL

MR. KAI MILLYARD/MS. JOANNA KIDD

STAFF RESEARCHERS
POLLUTION PROBE FOUNDATION

WHY ASSURANCES THAT DRINKING WATER IS 'SAFE' DON'T WASH ANYMORE

Notes for a presentation to the

National Drinking Water Conference
Westin Hotel, Ottawa, Ontario
February 6-7, 1984

By Kai Millyard and Joanna Kidd
Staff Researchers, Pollution Probe Foundation

WHY ASSURANCES THAT DRINKING WATER IS 'SAFE' DON'T WASH ANY MORE

So far at this conference, you've heard from a lot of experts; government experts, health experts, GAC and ozone experts, point-of-use device experts, and environmental law experts. Pollution Probe is really here to try and represent the public and their concerns.

A growing segment of the Canadian public has lost faith in scientists and politicians on drinking water.

Why? First of all, and most important, people know what's going into natural waterways. If they read the newspapers, they know that the IJC keeps finding more chemical pollutants in the Great Lakes every year. Two years ago the number of chemicals was 381, and in November it was reported that the number is up over 800. (1) They also may have heard that for the first time in a decade that the concentrations of some chemicals in the Lakes are on the rise. (1)

And the headlines scream out at them:

"Quebec faces clean water shortage" (2)

"River of waste threat to 500,000" (3)

"Pollution ends fishing" in B.C. (4)

"Great Lakes polluted by airborne toxic chemicals" (5)

"Hamilton Harbour pollution tops" (6)

"Two nation study finds 300 polluters on Niagara River" (7)

"Leakage turns water into 'toxic brew'" (8)

"More radioactive waste spilled into Lakes, Hydro says" (9)

And finally, "Don't drink the water", the Globe & Mail editorial from last June.

They also hear about overflows and spills and inadequate treatment at sewage treatment plants. And they even see for themselves oil slicks flowing down streams. We get regular phone calls from people reporting oil slicks in Toronto Harbour or chemical slicks flowing down the Don River.

But despite all the headlines and the studies and the rhetoric on water pollution, politicians and officials keep saying the water is "safe" for drinking.

Although reassurance has been the intended message every time, occasionally some mixed messages come through, which is telling.

For example, on the same day as former environment minister John Roberts got front page headlines saying a chemical dump is turning the water into a toxic brew, he also said that "within the framework of current scientific knowledge, neither the federal government nor the Province of Ontario has ever found any reason to believe that our water supplies are unsafe." (10)

A Toronto politician, backed up by a line of half a dozen Ministry of the Environment experts last year reassured the Toronto public that despite the over 50 contaminants in their water, that "we have the best drinking water in North America" and "there is no reason for any concern", and "any (chemical) traces...are no hazard to the public". He added that there's no danger from long term exposure to low levels of pollution, and that if anyone comes up with a better filtration system, Metro would be happy to spend what it takes to install it. (11, 12)

Ontario's former Environment Minister Keith Norton had his own words of comfort; "Metro's water is perfectly safe". (13) He later started an advanced drinking water treatment research project, and appointed a special committee of scientists to find out just what the effects of low levels of toxics are in the environment.

Last July, a Toronto news story basically read: We've found dioxin in Lake Ontario tap water, no, wait a minute, we haven't, it was probably contaminated in the lab. (14) Reassurances offered to people are often based on scientific speculation. 'We've found dioxin in Lake Ontario but it's OK, conventional filtration will likely remove any dioxin from the drinking water. (15)

Stories like these reinforce to the public, I think, that in terms of water quality, government **does not** have all the answers, although they often intimate that they do.

GUIDELINES

We are hearing the word "safe" less often these days, compared with 2 years ago. Now water supplies are "within the guidelines". The inference being that the guidelines are adequate to protect public health.

That's not very convincing to some people. The guidelines are hardly comprehensive. The ordinary citizen knows about the hundreds of chemicals in the Great Lakes. Over 40 synthetic organics have been found in Toronto's water, yet there are guidelines for fewer than 20. **How can this be reassuring?**

The citizen who starts looking into the guidelines in some detail stands to become rather confused. One of the most obviously confusing examples is in internationally differing Trihalomethane (THM) numbers. Canada's Maximum Acceptable Concentration (MAC) is 350 ppb, the US standard is 100 ppb (average), the World Health Organization (WHO) recommends 30 ppb (for chloroform), the European standard is 25 ppb and West Germany's proposed guideline is 1 ppb.

The very existence of guidelines in the first place implies that there are 'safe' levels. The word, and idea of 'safe' has an unfortunate tone of absoluteness about it. For many contaminants we now know that not to be true - just different risks associated with different doses, especially carcinogens. So now we talk in terms of "acceptable risks". Two obvious questions then arising are what level of risk is acceptable, and who is deciding what "acceptable" is?

A third question arising is what level of risk is reflected in the current guidelines? To answer this, I have done a brief analysis of the guidelines for the carcinogens that have been found in Toronto's water. (See table). The left column lists the contaminants, and the next is the carcinogenic "potency", expressed as the amount required to produce 1 additional cancer in 100,000 exposed. The third column contains the current guidelines, and the last is the number of additional cancers we might expect over a lifetime **if the carcinogen was at the MAC,** per million people exposed. I am using the per million figure because it is the figure that the National Research Council has coined as a 'virtually safe dose'. (16) I must also emphasize that we do not see levels of these chemicals anywhere near this high, and we all know the uncertainty associated with this kind of predictive risk assessment. But it is a valuable exercise towards understanding what common safety factor is used in setting the guidelines. And I think the answer is clear: none. No particular margin of safety has been applied. To the citizen looking for logic, rhyme or reason in our drinking water guidelines, it would appear that policy makers have been playing 'Pin the Guideline on the Pollutant.'

It is also clear from the table that many of these levels appear to be set very high - at levels which many people may not consider acceptable at all.

The question to be asked here is 'how should standard setting be done, and what is the role of scientists in setting

Predicted Additional Lifetime Cancer Risks in Humans Resulting from lifelong ingestion of Carcinogens in Drinking Water at "Maximum Acceptable Concentrations"

Carcinogens found in Toronto Tap Water	Chronic Exposure Level* Resulting in 1 Additional Cancer in 100,000 exposed	H & W Canada Maximum Acceptable Concentrations	Predicted Additional Cancers per 1,000,000 exposed at M.A.C. levels
Arsenic	20 ppt	50 ppb	25,000
Cadmium	10 ppb	5 ppb	5
Chromium	50 ppb	50 ppb	10
Chloroform	1.9 ppb	350 ppb	1,842
Bromodichloromethane	1.9 ppb		
Dieldrin	.71 ppt	700 ppt	9,859
Heptachlor Epoxide	2.78 ppt	3000 ppt	10,791
Lindane	186 ppt	4000 ppt	215
PCB	.79 ppt	3000 ppt (MOE)	37,974

* Taken from the Handbook of Toxic and Hazardous Chemicals M. Sittig. Noyes Publications 1981
Sources: International Agency for Research on Cancer
U.S. Environmental Protection Agency
U.S. National Academy of Sciences
U.S. National Research Council

public policy?' I think we have to distinguish between the two separate aspects of this process - gathering or generating the science and estimating risks, and the making of value judgements - which is not a scientific question at all. Anyone can decide what an acceptable risk to them is, given the information. But it would appear that scientists have been making value judgements on 'acceptable risks'. One of them told Pollution Probe last summer that the numbers were not set on health grounds, but on the feasibility of achieving those levels. This is why Pollution Probe believes that acceptable risks should be set by publicly accountable politicians after public participation and debate.

There are other, perhaps more obvious problems with the guidelines, which also contribute to public skepticism. For instance, the guidelines we have are set for single chemicals, and don't even consider the "chemical soup" we are dealing with these days, in groundwater as well as some surface waters. The reality is that pollutants often come together, and there may be additive effects at work. I think Howard Ferguson of Environment Canada put it very well at the IJC meeting in Indianapolis in November, when he said:

> "Reason tells me that while I might be able to accept the risk associated with a given concentration of a single chemical in my drinking water, I am going to be much more unwilling to accept the total risk represented by a larger number of chemicals - all within their acceptable limits..." (17)

The possibility of synergistic effects as well throws even more doubt on the the meaningfulness of having numbers for individual contaminants - reality is getting further and further away from the controlled lab conditions with one chemical which produced the guideline number in the first place.

So? For all these reasons people are beginning to realize that science cannot really tell us if the water is safe or not. Politicians keep saying it is, although they have no proof - but the public doesn't believe it. In a recent poll of residents living in the Niagara River area a majority of those asked felt that the river water was not safe to drink, even though it meets the guidelines. Forty percent of them felt it was already causing an increase in disease in the area. In a 1982 poll over half of Ontarians asked thought that there had been little or no success at cleaning up the Great Lakes. Nationally, 62% of those polled stated that cleaning up the Great Lakes was of 'critical concern'.

People are simply perceiving that the agencies responsible for protecting health and the environment are not doing their jobs.

And so they're angry and suspicious. They're going out and spending millions of dollars a year on bottled water. (18) They're buying home tap water treatment devices some of which don't work very well. They're signing petitions, and they're writing to their politicians, and they're getting organized.

And so politicians now have a problem. Governments are going to have to do more. Annual conferences aren't going to be enough. Studying carbon filtration won't be enough. And I'll bet setting a few more guidelines won't be enough either.

What can they do? In the eyes of the public, government should do seven things, only some of which are regulatory or legislative.

- The first and best solution is to clean up the pollution at source. But we all know that is a long term battle. And in the meantime,

- Government should develop a coherent, comprehensive and defensible federal policy on drinking water, since there doesn't seem to be one, at present.

- Government should involve the public in standard setting and in setting 'acceptable levels' in an open process. The people who are going to assume the risks should have a voice in setting the acceptable risk levels.

- Government should introduce Safe Drinking Water Acts, both federally and provincially.

- Government should recognize the limitations of the single chemical approach in some situations, and develop an 'aggregate standard' of some sort for sources which are contaminated with many pollutants. Perhaps this could be a combination of Total Organic Carbon and an Ames mutagenicity test. Dr. Schalekamp mentioned earlier that the Swiss have a 1 ppm standard for TOC.

- Government should acknowledge that there may be a need to install advanced treatment in some areas, even if we aren't able to scientifically measure and predict the health risks involved.

- Finally, they should not worry about the money it will cost to upgrade treatment plants. If a great enough problem exists, the public support will be there. No government is going to fall over clean water.

Thank you.

Footnotes

(1) International Joint Commission, Great Lakes Water Quality Board Report, November 1983.

(2) Toronto Star, August 3, 1980.

(3) Toronto Star, October 14, 1981.

(4) *The Montreal Gazette* (CP), October 30, 1982.

(5) *The Ottawa Citizen* (CP), November 17, 1982.

(6) *The Globe and Mail*, November 17, 1982.

(7) *The Globe and Mail*, February 16, 1983.

(8) *The Globe and Mail*, January 25, 1983.

(9) *The Toronto Star*, September 7, 1983.

(10) Speech notes for the Honourable John Roberts, Minister of the Environment, Niagara-on-the-Lake, June 6, 1983.

(11) *The Globe & Mail*, March 3, 1983.

(12) *The Toronto Sun*, March 3, 1983.

(13) *The Toronto Star*, October 31, 1981.

(14) *The Toronto Star*, July 5, 1983.

(15) Ontario Ministry of the Environment, Press Release, February 22, 1983.

(16) NRCC, *Polychlorinated dibenzo-p-dioxins: Criteria for their effects on man and his environment.* 1981.

(17) Speech notes for H.L. Ferguson, International Joint Commission Great Lakes Water Quality Conference, Indianapolis, Indiana, November 1983.

(18) Personal communication with Wayne Smart, President, Crystal Springs Water Supply Company, Malton, Ontario. February 1983.

UNEDITED TRANSCRIPTION

Questions, Answers, Discussions

Jerry Ronan,
Ontario Ministry of the Environment

I think we have seen a classic display of the rhetoric of hysteria which a lot of the speakers have suggested we should try to remove from this debate. And I'd like to pinpoint some of the factual inaccuracies contained in the presentation.

Number one: there has never been any dioxin found in any Ontario drinking water. Number two: we have discussed here today and yesterday the fact that water supplies, the meaning of safe, and what's really at issue is that we have potable water supplies in this country, in Ontario, but we can make them more safe or better quality if we introduce more expensive treatment technologies. And this is a key theme which has been addressed throughout these two days of discussions. So, there was a reference to last year when there were allegations that Metro Toronto was in dire parol because of an alleged interpretation of data which was produced by this Pollution Probe. And to respond to that, it's necessary to allay unnecessary anxieties in the public when these kinds of exaggerations are tabled. And unfortunately, when officials are placed in these circumstances, there are many levels of response. One of the important ones is to try and tell the public or pregnant women that their children are not under stress, there is not a terrible threat. It's these kinds of words - they harm the discussion and I think they are counter-productive towards getting any forward development in policy evolution.

Mr. Edward has also used the same words as his "wrap-up." He said, "Water is a significant matter, and there are many hazards." And I think the past two days have indicated that has not been demonstrated in the Ontario context. And I think it's important to choose your words carefully if you want any real response to the positions you are putting forward.

Joanna Kidd

The reference I was making about dioxins were in Ontario water was in a press release by Keith Norton saying that we have found dioxins in three samples of raw water, surface water. That's what I said in my speech! Lake Ontario water! And I would at this point like to clear up something once and for all. Some members of government allege that someone from Pollution Probe once said - linked drinking water and pregnant women. That, in fact, was not the case, was never the case. When it comes to words like "alarmist," the only time I heard that in connection with drinking water, apart from your little speech today, is from Metro Chairman Paul Godfrey. And he is the one who keeps bringing out those words out of the closet and saying, alarmist, alarmist, alarmist.

David Simpson,
FACE

Okay. Can we have - we don't want to superimpose Metro Toronto's debate on our national forum, although it's one of the critical ones. I think some of these old wounds, we don't want to open them up. Let's try to keep it to some of the policies and philosophies that have been postulated by our speakers from Doug Edward's requirement for an act through the risk assessment, critical assessment of Dr. Somers, through to the 7-point proposal by Pollution Probe of what can be done. Let's try to keep the debate at that level. I'd like to hear some simple questions. I know we have got a lot of people out there in the audience that are just plain old water treatment guys. And I would like to invite you to get up and ask just a plain old innocent question about where do we go from here or something like that. So don't be inhibited by the group we have.

Trevor Hancock,
Department of Public Health

One quick comment and one question to Dr. Somers. The comment is that I think that getting into the whole argument about the specific level of this chemical or that chemical gets us away from the much broader issue that Dr. Schalekamp raised from Zurich which is that we should really be trying to provide water that is as clean as we can possibly make it, particularly given that we don't know what the results of a multitude of chemicals are, even if we are clear on what one individual chemical might do. And I think we shouldn't lose track of that; that that is the crucial issue; what is the best water that we can provide, and people are willing to pay the price for better-quality water.

My question to Dr. Somers: he made some I assumed positive references to the U.K. and Swedish experience with involving people in decision-making around risks. You were talking within the occupational health setting primarily. I would hope that you would respond positively to the suggestion that in re-examining the MAC's, as is currently going on, that same philosophy should be adopted and that public involvement in commenting upon and examining the rationale for and helping to establish MAC's would indeed be welcomed by Health and Welfare Canada.

Dr. Emmanuel Somers,
Director General, Health Protection Branch

I have a comment to make on your general suggestion. I like to bring it up because it has been raised a number of times. And that is the suggestion of synergism or potentiation. I am always interested to see how many times the question of synergism or potentiation of chemicals is raised and how rare, in fact, that effect is as a biological occurrence. I mean, it's certainly possible and nobody in their right mind would say, you are wrong, because it is impossible to say that. But there isn't a lot of evidence of a massive synergism of toxicity in one chemical or another. There is some, there are some cases and I can read them out and I have written papers on them. But not a lot. It's quite a rare occurrence.

Well, let's talk about your question, about the work that is going on at the moment, to develop guidelines. What I suggest to you as possible approaches for Canadian legislators is quite a different proxy versus what is possible in the current system, either way we develop it. There is no question that we want all the possible scientific one can have into the development of any regulatory mechanism. One spends a lot of time asking skilled and knowledgeable people to give on advice on these questions. The word you kept on using was "public." I don't think that public debate is the way to settle whether we should have 1 or 3 parts per million of any particular count of contaminants. That's my own personal view, by the way.

Now if you talk about the way other people should be involved in the actual decision-making, that's another question. And that has to be thought out, worked through, and schematically dveloped, certainly not legislatively, certainly administratively. What I gave as examples two was the way the Swedes in particular have used it on the food side, the way both the U.K. and the Swedes use it for occupational health. There is not a public debate, there a representation of groups that meets.

Trevor Hancock

I make a point about your first point and then about your second. My first point is that again in some ways, as a very simple individual, it seems to me that there is an issue of common sense around the whole issue of synergism, too, which is giving you a choice between drinking one carcinogen or being exposed to one carcinogen and being exposed to ten, which would you think is likely to be more dangerous. Or 100, or 1,000 or whatever. There is an element of common sense in there, it seems to me. That's also science, mind you.

The second point is what I am looking for is when I say public debate, I mean that if a set of guidelines are being promulgated, prior to their being promulgated, they should be circulated for public comment so that - and together with the rationale on which they are based. So you have to debate, which is going to happen anyway, prior to promulgation rather than after.

Don Fast,
Saskatchewan Environment

I would like to make a comment on the conference and then ask a question. My comment is that while overall I think the organizers are to be congratulated for an excellent program and an excellent conference, I did observe that both of your key speakers on the public interest and the public issue questions were speaking on the U.S. experience. And from my perspective, I would have preferred someone to address the Canadian experience in a higher profile than has been done. But I think that's maybe a minor suggestion and overall it's been a very good conference.

My question pertains to the matter of payment of improved water treatment works. I think that over the last couple of days we have heard a lot about technology that is available and the fact that more could be done to improve our drinking water quality. In Saskatchewan, in 1983, we had some public hearings on water and found that the public seemed to be demanding improved treatment. But there is some uncertainty as to who whould pay - the municipality, the province, the federal government: who should pay? And I like to hear the opinions of the panel on that.

David Simpson,
FACE

I just make a quick comment. One of the reasons we have used the American public interest is because they have been through this whole act. And we are using this experience.

The other thing, with respect to who pays: if you own land, live in a province, in a federal... it comes out of somebody's pocket and it is usually yours. So it's just a matter of jurisdiction.

Doug Edward

I was just going to say exactly the same. There is no question that improved treatment facilities are going to cost money. And it is going to be taxpayer money in the end result. So whether the municipality raises real property rates of whether the provincial or federal governments raise income tax rates in order to pay for it, it's still coming out of the taxpayer's pocket. And I think one of the things we have heard, stated time and time again, is true that the taxpayer is prepared to pay at this time for assurances that the water supply they are getting is as clean as possible.

Frank Hogan

My name is Hogan and like Bob Goodings this morning, I am a plumber. And I have one very simple question. With all this high rhetoric about this quality of Ontario's water, and I would be the first one to admit that I wouldn't drink Lake Ontario. But I was wondering what does Miss Kidd drink when she is in Toronto if the water is so bad.

David Simpson

Frank, could you identify where you are from?

Frank Hogan

Halifax, Nova Scctia.

Joanna Kidd

I tend to drink beer, but no... I actually drink a mixture. When I am at home, I drink springwater that I buy. And when I am at Pollution Probe, I drink Toronto tap water because that's all we have. And, incidently, I drink springwater for aesthetic reasons mostly because I like drinking tea, and tea and chlorine do not mix.

Ellen Lipsius

I work in the area of preventive medicine and I come from Toronto. I have enjoyed the conference very much. I am not in the hard sciences but I understand a great deal of what has been discussed here today. But I feel rather like Alice in Wonderland. It's very, very curious. It seems to me that the Emperor really does have no clothes. Why have we been merely discussing treatment of contaminated water after it's arrived at its source for distribution, rather than also at least concomitantly discussing technologies for helping private business, public utilities to get rid of their methods. They are contaminating our water and the health of the public. It seems to me that the public should not be paying the whole bill for this. I think that this is a question that is begging to be answered. Thank you!

David Simpson

I would just say that in terms of... on behalf of the steering committee that we had such a broad issue and we wanted to focus on this one, on drinking water, and what the issues are once we get the water from our supply. There is no question that that is a major point and should be addressed perhaps in another forum, another session.

Doug Edward

I was just going to say that your concern is very well founded. In fact in the formal paper that I gave Dave a copy of, I have stated quite clearly that these concerns are not intended to deflect our attention from the prevention of pollution. But there are myriad problems in preventing pollution and enforcing those preventive measures and until we work those out, we still got the problem of the chemicals in the drinking water.

Bob Reid,
Winnipeg, Manitoba

We have a small bottling operation as well as a line of point-of-use home treatment things. The last lady that spoke mentioned Alice in Wonderland and I think there is paragraph in the book where there is a bottle that says, Drink me! And I think she refuses until she knows what's in it. Actually, that's what led us into our whole business several years ago. Because having heard all the dialogue here, I like many people in this room - I don't know who to trust any more. So I don't trust anybody but me. And everything I drink and cook with hapens to be distilled water. And that seems to be maybe the perspective that this conference is looking for because to me, in this day and age of mounting carcinogens and mounting pollution no matter where you go, it seems absolutely inane to treat 100 gallons per water per day per person when all you use for drinking and cooking is probably 2. So if we can kind of wrestle with that one for a little bit, it just might be that we change our perspective as to what are we doing with this water. Anytime when I am making some remarks or when when I am speaking to anybody, I like to make the point that in my opinion everybody should have three kinds of water: the first kind you get is what is delivered from the municipality or what comes out of the well or the lake or the river. Now that comes to your door. Now once you get it there, you can use that to water the lawn providing there is not too much sodium or alkaline in it or whatever, or put out the fire at your chesterfield if your house starts to burn down. But thereafter it should be treated for the purpose for which it is going to be used. The first purpose, of course, is washing and cleaning and bathing. That's where the biggest treatment comes in. And then the final one is that one or two gallons per person per day for drinking and cooking. And in all my readings and in all my studies, and in my library I have got as big a bibliography as anybody I suppose when it comes to references, and all I notice when I read in books, and there seem to be a lot of people out there that share my concern about the type of additives that are going into the water from the chlorine to the fluoride, the asbestos fibre, etc. etc.

So just the bottom line point I'd like to make here is that I think that if we just adjust our position on that kaleidoscope by a couple of degrees and look at this from a different perspective, then maybe collectively we can come up with something that will fit, and it will fit no matter where we go in the country. Thank you!

Sam Kline,
Kline Engineering

I have a question for Dr. Somers. And I would like to refer to something Mr. Roy Hickman of the Health Protection Branch showed on the screen. And that was in particular the quantity or the litres of dinking water we drink per day. And there was a very interesting statistic there that soft drink accounted for approximately 30 to 50 percent of that 1 point whatever litres figure there was. And the question I am going to ask Dr. Somers: a letter was written to Monique Begin bringing to her attention the fact, based on research done by our company, and the actual THM's were measured by the Ministry of the Environment of Ontario, it is still adequately possible to have as much as 10 times the quantity of THM's that are normally found in drinking water coming out of your taps, in soft drinks. And the rationale behind it goes something like this...

David Simpson

What I am a little concerned about is that we want to try to zero in on questions that are policy to acts and perspectives. So if you can sum it up quickly, and then we can move on.

Sam Kline

Okay, I try my very best. Number one, we were a little bit surprised to discover that soft drinks come under the jurisdiction of the Food and Drug Directorate. It has nothing to do with provincial jurisdiction. And we wrote to the soft drink industry bringing to their attention the THM's. Now we wrote to the Minister of Health and Welfare. We would like to know what is the status of the investigation.

Dr. Emmanuel Somers

Let me tell you that the sale of soft drinks is subject to the Food and Drugs Act. And therefore it is federal jurisdiction. There is no question about that.

In terms of the answer to your letter, when I go back I find out what's happened to it. As a matter of fact, I am interested in that particular question because it was raised to me in another context no more than two weeks ago, about the differences of occurring in those materials which are subject to the Food and Drugs Act. For example, bottled water is. And the standards for bottled water are not, as I remember them, in the same as those which are guidelines for the provinces. And there can be differences in that way. I think that is something which ought to be thought out. But I don't know where we are with the trihalomethanes in soft drinks. But I also saw a reference that it could be higher. So when I go back I find out what's happened to it.

Linda Duncan,
Executive Director,
Environmental Law Centre Alberta

I have a very quick question and comment. I thought that I couldn't resist standing up. I thought I had to add that because there should be a national conference centre in Alberta. I thought that I had to add that because this should be a national conference, and I wanted to hear more of what's happening elsewhere than in Toronto. I think this conference has been terrific! But there seems to be one thing missing from the panel up-front, and it's regrettable. I think that the issues raised by the speakers are commendable, and particularly those of Mr. Edward. The Environmental Law Centre in Alberta has similar concerns. The headlines in the paper are the same: "Don't drink the water!"

What I would appreciate here is a very quick response from any official here from a department of environment who has responsibility to respond to the policy recommendations that are being made. And I am wondering if Mr. Edward can give us any information on if he has received any response from any of the levels of government, including outside of Ontario and Toronto, as to suggestions for reform.

Doug Edward

Well, I haven't received any responses from outside the province of Ontario. But I have had discussions with persons with Health and Welfare Canada who have indicated that draft legislation is being prepared. So that this is being considered and perhaps has been prepared and has been worked through a couple of drafts. So I suppose that indicates that there is a commitment at least at one level of government to take this matter forward as far as possible given the circumstances.

David Spink,
Alberta Environment

A comment on something that Mr. Edward said. Firstly, I don't have any problem personally with what's being proposed by Mr. Edward and his group. I am not sure it's that much different than what we already have in terms of most of the provinces and how we handle drinking water regulations and enforce them. I was interested in his suggestion that the provincial agencies should be responsible for enforcement which is, of course, the hardest part of the whole exercise. I think that the difficulty comes in setting a standard is that the public perceives a standard as a wall. And if you are on this side of a standard, you are fine. If you are on the other side of the standard, you're in big trouble. And the difficulty we have with standards as soon as somebody, a municipality, exceeds the standard, people perceive that they are at risk and they get very concerned. And, you know, even when it relates to some of these aesthetic parameters like iron manganese or some of the heavy metals where maybe if there was a sustained violation of a standard of a maximum acceptable concentration, there might be a risk. But if a lead level exceeds the maximum acceptable concentration by 10 percent, 1 sample out of 10 a year, it's very difficult for us to get too excited about enforcing and coming down hard on that municipality, but people perceive that something has to be done because they perceive the standard as the absolute maximum you can go to. So I think when we talk about standards and enforcing standards, we have to recognize that judgment has to be used and this is often where we run into problems with the public-interest groups who have their hearts and their minds in the right place. But it is very difficult for us as the enforcement agency, and to maintain credibility with communities we act on a lot of their suggestions.

Doug Edward

If I could just respond to that. The points that you are making are well taken to a certain extent. But we don't shy away from standard-setting in other areas because of the fact that some people may perceive the standard as a line beyond which "thou shall not pass." And we also have, in my opinion, in some cases far too great a discretion in the hands of governments as to whether or not a prosecution is going to ensue when a standard is exceeded. We have these two mechanisms to ensure that we don't come down with sledge hammer on a fly. And I think that answers that concern.

The other issue, really, is the public's knowledge of the standard and of the process by which it was set and I think that the remedy there, obviously, is to have as great a level of public participation in the setting of the standard as you can possibly work into it. And only then do you have a full public knowledge and confidence in relation to the standard. And I think then you'll see that reaction that you are talking about to diminish to a certain extent. We haven't really had that public involvement in this country yet. And I think that's the problem. That's why we have this legacy of deep, deep mistrust of government in the environmental area. The public has not been systematically included rather than systematically excluded from the standard-making function.

Daniel Green

I think it's a good idea to try and establish Canadian standards. I think the constitutional problems will be so great that nothing will happen. And I think Health and Welfare knows this. And this is why we are going ahead with you because we know that Quebec will never accept a Canadian flag on any of their water treatment centres because it's far worse now and this is happening in sewage treatment. Quebec refuses money from Ottawa - but Ottawa gives money directly to municipalities - for sewage treatment. Give the money to us and we will unanimously give the money to municipalities and only put a Quebec flag at the sewage treatment facility. So the same thing is with water treatment. I think Health and Welfare and Monique Begin of all people knows this. And so this is why Health and Welfare seems to be coming about. But I think the bottom line is that it might end up in the Canadian Supreme Court. Can Ottawa tell Quebec - Quebeckers or Albertans or New Brunswickers how much chemicals they can have in their water. So I think it's a good idea to try the process but I think that we are really opening up a bag of worms. I think it's up to every government official and every environmental group and every citizen, every province to ensure themselves they have good clean drinking water. And that if Health and Welfare can give us a hand by giving us good data, fine! We make it public and open up the process. But with legislation, you are opening up a can of worms, I am afraid.

Dr. Maarten Schalekamp

Very short and only a comment. The most important thing, I think, that is that you look for your waste water and clean it up. That's one of the points. And, of course, also the treatment effort is necessary for the water quality. I can't say if it is necessary or not. But one thing: let the peole do that who are working for the sewage and for the drinking water and for the littre. We do it also. And use them, not the government, of course not. The men who use your water, the men who polluted the water, you bill them three parts; one part is for the drinking water, the other part is for the sewage water, and the third part is for litter. And if you give it to the people and they will pay for it. And I tell you, we have to vote for every cost, every project that costs more than 10 million Swiss Franks. And you can understand that if you have a treatment plant, it costs 250 million Swiss Franks or 500 million, that they vote "yes." Because they want to have good water and they want to have no sewage in the rivers and in the lakes. And therefore I would say, bill it to the people, and then you have no problem. Not the government, the people, the communities who are responsible for the drinking water, they should also do it for the sewage water and for the litter. And they have no problems, they can solve your problems.

Kelly Kjartensen,
Manitoba Environment

I guess there were two points that I wanted to discuss, being a provincial representative first, although I resent the implication made by one of the panelists in particular that the provinces have been dragging their heels on the matter of drinking water. One particular point that should be brought up is the fact that many of the provinces have in fact been lobbying Health and Welfare Canada to come out with this Safe Drinking Water Act.

Many of the speakers have said that it doesn't matter what pocket the money comes out for many of these expensive treatment schemes and the complex analytical services, etc. But from a provincial perspective, the money is not free and easy. We don't have money trees in Manitoba. It's much easier if a federal agency takes the lead in, say, setting guidelines and offering complex analytical services and providing monies where we are running into very difficult water treatment problems. So I would challenge those who say the provinces have been dragging their heels.

The second point I wish to make with respect to the public participation aspect in which it was applied that government is acting as Big Brother and is more or less bullying regulations and guidelines through. In Manitoba, we have been working on a public water system regulation for the past six years. We have had many mailings to public-interest groups, municipalities, etc. And I can show those that are interested the responses we got. And I can tell you, the percentage of response from the people we have sent the mail to was very discouraging. So it's one thing to say the public should be involved. But it's another thing to get them involved.

Doug Edward

Yes, I just like to respond to that. I am sympathetic to your attempts to get the public involved and I didn't mean to indicate that it is still the case today, that the public is systematically excluded from all participation in standard-making. I think I can confidently say that ten years ago, that was still the case. I think governments today are changing their viewpoint because they have been burnt too often. They have gone ahead and set a standard and somebody from the ignorant public has come forward with information that has shown them that it simply was not adequate. And as a result, I would say that now governments are looking to methods of getting the public involved in standard-setting. But I would say my comment is not for ten years ago and maybe even as far as five or six years ago.

The other thing about legislation, enlightened legislation very often, if you study the U.S. example and sometimes the Canadian as well. When we talk about the taxpayer, the direct impact on the municipal tax rate is enormous, and federal legislation very often nudges municipal and provincial legislation into action. So I would substantiate your point. But the history of legislative studies indicates that usually it takes individuals or governments removed from the source of the problem to dispense the funds and then it comes along. So I substantiate that point as well.

Pat Hansen,
Windsor, Ontaro

I am an English teacher. And I am your average ignorant public. That's me! And for the last six months since I have been reading papers on trihalomethanes, various other chemical contaminants, I have read stuff from the IJC, I read stuff from the health hazards and so on and so on. I am not familiar with them but I have learnt a little bit about them because of my concern about Windsor drinking water. And I would like to say that I have had some help from government departments in getting hold of information, but I certainly would have liked a bit more. And that I am very grateful for the help that I have had from organizations such as Pollution Probe. They are free with their information. They are not afraid to speak out. They are not worried about losing their jobs which seems to me that most government scientists and politicians may be, and water engineers in municipalities as well. So I think that we need people like that. I don't consider Joanna Kidd hysterical in the slighest, and I share with her many concerns, a few of them which I think Dr. Somers missed. I am sure he didn't really. But these are the ones I feel perhaps he didn't consider when he was trying to allay anxieties.

First of all, the long-term effects. He may have mentioned that he didn't seem to consider their seriousness and I feel very strongly that we should be working now, because of the long-term effects of low-level contamination in drinking water - now is the time, I mean it's already late, that now is the time! No, we don't have to wait for yet more research and yet more projects on GAC to see whether it works or not.

I am worried about accumulative effects as well as as the long-term effects. I am worried about the damage to groundwater. I am worried about the latency of cancer. We now see the effects of pollution that happened some years ago. What's it going to be like in 20 years from now? It seems to me, from what I have read, that the cost of installing improved water filtration in municipalities would be at the most 20 dollars per family per year. And I read similar figures in two or three different sources. And I don't think that if people were concerned about water, they would mind paying that.

My question is, because scientists and government people seem concerned more to reassure us and to patronize us than to think us intelligent enough in our response to drinking water problems. Who is going to speak for the public? Who is going to speak for us if it isn't Pollution Probe? Why are we being always reassured? Why are we not given information freely and told that our responses are intelligent and that indeed something should be done.

Dr. Emmanuel Somers

You know, I think when you make that sort of a remark, you are not really thinking about what the provinces and the governments - federal or provincial - do in terms of providing a great scientific establishment, limited in its way, to provide you with those evaluations. I mean, the whole system is devoted to trying to answer questions. And the reason we sponsor this whole meeting is precisely because we want to know what the concerns are, and we want to know what we are ought to do. We try, I suppose, to put things in context. I wasn't talking about drinking water contamination. Because I thought you have heard enough of it already. What I wanted to talk about is the way you try to assess risk, and the way you try, from the assessment of risk, make a policy decision from where you are in that interface between science and politics. That's what I was talking about. There are lot of problems. Not only do we know the problems, we spend quite a lot of money trying to solve these problems. And that holds true for the provinces as for the federal government. And if you want to have that material, I am well-prepared to do that. I am amazed that you haven't been able to get the information from us that you want.

David Simpson

Okay. I think we wrap it up because I think everybody has... this debate and discussion is going to go on for some time. There are impending acts, and we hope that we see something pretty significant and substantive and providing the information that we shared and heard over the last couple of days will be taken into account in the development of either new guidelines or a new act or whatever the next few months - and hopefully it's months and not years - will give us.

I like to thank you all for coming and providing the forum in which the critical issues were addressed. I think we had a very, very profitable two days. The speakers, I know some of the international ones, were commenting on what a tremendous group of people we Canadians have in the water field because they articulate their points of view well, to have the four groups from such diverse points of view meeting and discussing in an enlightened fashion. They were quite amazed. And I think they feel that we are well on our way, as a small step, towards getting progressive water legislation in this country and, in fact, addressing some of the problems that we have heard highlighted today. So I like to thank you!

STEERING COMMITTEE

ROY HICKMAN	HEALTH AND WELFARE CANADA
PETER TOFT	HEALTH AND WELFARE CANADA
RICHARD TOBIN	HEALTH AND WELFARE CANADA
DAVID SIMPSON	F.A.C.E.
TOBY VIGOD	C.E.L.A.
KAI MILLYARD	POLLUTION PROBE

LIST OF SPEAKERS

Dr. Alex Morrison
A.D.M. Health Protection Branch
Health & Welfare Canada
Ottawa, Ontario
K1A 0L2

(613) 992 5567/2441

Mr. Blair Seaborn
Co-Chairman, International Joint Commission
18th floor, Berger Bldg.
100 Metcalfe Street
Ottawa, Ontario
K1P 5M1

(613) 992 2417

Mr. Paul Emery, P. Eng.
Director of Water Supply
Metropolitan Toronto
10th floor, Phoenix House
439 University Avenue
Toronto, Ontario
M5G 1Y8

(416) 947 8220

Dr. Ross Hall
Dept. of Biochemistry
McMaster University
Health Sciences Centre
1200 Main Street W.
Hamilton, Ontario
L8N 3Z5

(416) 525 9140

Dr. Kristin Shannon
Canadian Trend Report
1452 Drummond St.
Montreal, Quebec
H3G 1V9

(514) 845 9216

LIST OF SPEAKERS (cont'd)

Mr. David Kirkwood
Deputy Minister
National Health and Welfare
Jeanne Mance Building
de l'Eglantine Street
Tunney's Pasture
Ottawa, Ontario
K1A 0K9

(613) 996 8147

Dr. Robert Harris
School of Engineering
Room H-113
University of Princeton
Princeton, N.J.
08544

(609) 452 3000

Mr. Roy Hickman
Director, Bureau of Chemical Hazards
Health and Welfare Canada
Environmental Health Centre
de la Columbine Blvd.
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

(613) 992 8612

Dr. Joe Cotruvo
Director, Criteria and Standards Division
Office of Drinking Water (WH-550)
U.S. E.P.A.
Washington, D.C.
20460

(202) 382 7575

Dr. Pierre Payment
Institute Armand-Frappier
531 boul. des Prairies
Laval des Rapides, Quebec
H7N 3X7

(514) 687 5010

LIST OF SPEAKERS (cont'd)

Mr. Bob Goodings, P. Eng.
Vice President
Gore and Storrie Ltd.
1670 Bayview Avenue
Toronto, Ontario
M4G 3C2

(416) 487 1351

Dr. Maarten Schalekamp
Director, Zurich Water Supply
Waserversorgung Zurich
Bahnhot quai 5, CH 8023
Zurich, Switzerland

Tel. 01 435 21 11

Dr. Jack DeMarco
Cincinnati Water Works
4747 Spring Grove Avenue
Cincinnati, Ohio
45232

(513) 352 4641

Dr. Rip G. Rice
Rip G. Rice Incorporated
1331 Patuxent Drive
Ashton, Maryland
20861

(301) 924 4224

Dr. Lee Wickstrom
Canadian Water Quality Association
472 Lee Avenue
Waterloo, Ontario
N2K 1X9

(519) 885 3854

LIST OF SPEAKERS (cont'd)

Dr. Victor Kim
Director, Office of Drinking Water
(WH-550)
U.S. E.P.A.
Washington, D.C.
20460

(202) 382 5508

Mr. Doug Edward
President
Canadian Environmental Law Association
8 York Street
5th floor S.
Toronto, Ontario
M5J 1R2

(416) 366 9717

Dr. E. Somers
Director General, Environmental Health Directorate
ENvironmental Health Centre
de la Columbine Blvd.
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

(613) 995 6015

Mr. Kai Millyard/Ms. Joanna Kidd
Pollution Probe Foundation
12 Madison Avenue
Toronto, Ontario
M5R 2S1

(416) 978 4171

CONFERENCE PARTICIPANTS

NAME	AFFILIATION
ALLEN, KEN	KINGSTON P.U.C.
ALPAUGH, CATHY	
AMYOT, JEAN PIERRE	LIBRARY OF PARLIAMENT
ANDERSON, JACK	LEAMINGTON P.U.C.
ARBUCKLE, TYE	HEALTH PROTECTION BRANCH
ARMSTRONG, VIC	HEALTH PROTECTION BRANCH
AUDET, CLEMENT	ENVIRONNEMENT QUEBEC
BAILEY, BILL	MINISTRY OF ENVIRONMENT, B.C.
BARTER, FRED	AQUA-SOFT SERVICE
BASUK, JACK	SCIENCE COUNCIL OF CANADA
BENEDEK, ANDREW	ZENON ENVIRONMENTAL INC.
BENOIT, FRANK	HEALTH PROTECTION BRANCH
BIENVENUE, MICHEL	
BLOCK, PETER J.	ONTARIO MINISTRY OF HEALTH
BONK, STEVE	REG. MUNICIPALITY OF OTTAWA/CARLETON
BOWERS, ANDY J.	SIMCOE ENGINEERING GROUP LTD.
BRAY, J.R.	MINISTRY OF ENVIRONMENT, ONT.
BUTLER, BILL	CITY OF ST. JOHN
CAMERON, ROSS	UNIVERSITY OF TORONTO
CASEY, PETER J.	DEPT. OF HEALTH, N.S.
CAVERSON, DAVE	ENVIRONMENT CANADA
CHARTRAND, RON G.	HALIBURTON, KAWARTHA, PINE RIDGE H.U.
CLARK, CLIFFORD G.	DEPT. OF HEALTH, REGION OF PEEL
COCKSEDGE, W.G.	HEALTH AND WELFARE
COLVIN, PHYLIS	HEALTH AND WELFARE
CONNELLY, BOB	F.E.A.R.O.
COOLICAN, D.M.	HEARING PANEL ON INDUSTRIAL WASTE MGMT.
COTRUVO, JOE	SPEAKER, U.S. EPA
COUET, SUZANNE	DEPT. OF COMMUNITY HEALTH, MONTREAL
CRAIG, JIM	PETERBOROUGH UTILITIES COMMISSION
CULLEN, DOUGLAS	ENVIRONMENT CANADA
DAGAMA, H.	REG. MUNICIPALITY OF OTTAWA/CARLETON
DAVEY, STEVE	WATER & POLLUTION CONTROL
DAVIDSON, CHARLES M.	CIL RESEARCH LAB
DAVIES, KATHERINE	DEPT. OF PUBLIC HEALTH, TORONTO
DAVIS, A.R.	DEPT. OF ENVIRONMENT
DEMARCO, JACK	SPEAKER, CITY OF CINCINNATI
DOMINIE, KEN	DEPT. OF ENVIRONMENT, NFLD.

CONFERENCE PARTICIPANTS

DOUGLAS, GEORGE	HEALTH PROTECTION BRANCH
DOUGLAS, SHARON	P.A.C.E.
DOVER, PEGGY	
DOWDESWELL, ELIZABETH	ENVIRONMENT CANADA, ECS
DROUIN, HUBERT	CANADIAN DENTAL ASSOCIATION
DUDECK, ALAN	MEMBER, LOCAL BOARD OF HEALTH, TORONTO
DUNCAN, LINDA	EDMONTON, ALBERTA
DUNCKLEY, G.C.	OTTAWA-CARLETON HEALTH UNIT
DUNN, ROBERT	ONTARIO MINISTRY OF ENVIRONMENT
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FERGUSON, HOWARD L.	ENVIRONMENT CANADA
FINDLAY, RICK	ENVIRONMENT CANADA
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FRANKLIN, CLAIRE	HEALTH PROTECTION BRANCH
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RICKETTS, FRANK	YORK UNIVERSITY
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RYAN, DENNIS	PRONVINCE OF NOVA SCOTIA
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SALLOUM, DUANE	ENVIRONMENT CANADA
SAMS, S.	REG. MUNICIPALITY OF OTTAWA/CARLETON
SATTAR, S.A.	UNIVERSITY OF OTTAWA
SCHALEKAMP, MAARTEN	SPEAKER, ZURICH WATER SUPPLY
SEABORN, BLAIR	SPEAKER, INTERNATIONAL JOINT COMMISSION
SHANNON, KRISTIN	SPEAKER, CANADIAN TREND REPORT
SHARINA, CHARLES P.	STRATHROY P.U.C., ONTARIO
SHEWCHUCK, PAUL	ALBERTA
SHIPLEY, KEVIN	CANVIRO CONSULTANTS LTD.
SIMPSON, DAVID	F.A.C.E.
SITWELL, JACKIE	HEALTH PROTECTION BRANCH
SMART, WAYNE	CRYSTAL SPRINGS BOTTLED WATER CO.
SMITH, DUNCAN	ONTARIO RESEARCH FOUNDATION
SMITH, JIM	ENVIRONMENT ONTARIO
SMITH, LOU J.	CANADIAN WATER QUALITY ASSOCIATION
SOMERS, E.	SPEAKER, HEALTH PROTECTION BRANCH
SPENCER, STAN	HAMILTON WENTWORTH REGION
SPINK, DAVID	ALBERTA DEPT. OF ENVIRONMENT
SUFFOLETTA, VINCE	REG. MUNICIPALITY OF HALTON
SYDOR, MAURICE	ENVIRONMENT CANADA
SYKES, GARY	NOVACORP ENG. SERVICES LTD.
TANNER, SUSAN	
THOMPSON, J.L.	COLLEGE MILITARIE ROYAL
TOBIN, RICHARD	HEALTH PROTECTION BRANCH

CONFERENCE PARTICIPANTS

TOFT, PETER	HEALTH PROTECTION BRANCH
TOSINE, H.	MINISTRY OF ENVIRONMENT, ONTARIO
TOWNSHEND, AL	ENVIRONMENT CANADA
TRACY, HUGH	PROCTOR AND REDFERN LTD.
TUPPER, C.E.	HEALTH AND WELFARE
VALLERY, DOUG	
VANDERLAAN, H.J.	TROJAN TECHNOLOGIES INC.
VIGOD, TOBY	C.E.L.A.
VILLENEUVE, DAVID	HEALTH PROTECTION BRANCH
WALKER, SYLVIA	CONSUMER AND COMMERCIAL AFFAIRS, SASK
WALLER, D.H.	TECH. UNIVERSITY OF N.S.
WALTERS, R.J.	AXEL JOHNSON INC.
WARREN, IVAN	ST. JOHN'S METRO AREA BOARD
WARWICK, O.H.	HEARING PANEL ON INDUSTRIAL WASTE MGMT.
WATSON, A.E.P.	INTERNATIONAL JOINT COMMISSION
WENSLEY, BYRON	SASKATOON COMMUNITY HEALTH UNIT
WHITAKER, RUTA	HEALTH PROTECTION BRANCH
WIKSTROM, LEE	SPEAKER, WATER QUALITY ASSOCIATION
WILLIAMS, DAVID	HEALTH AND WELFARE
WINDLE, WILETTA	HEALTH PROTECTION BRANCH
WINTHROP, STAN	HEALTH PROTECTION BRANCH
WOLOSCHUK, BORIS	WOLOSCHUK ASSOCIATES
WOOD, GRACE	HEALTH PROTECTION BRANCH
WORDSWORTH, ANNE	C.E.L.A.
WORLAND, ADELE	